



**Metropolitan Community College
Longview Automotive Institute
Metropolitan Community College
Lee's Summit, Missouri**

Permit Set - Volume 3 of 3
Divisions 21 through 33

DLR Group Project No. 13-23128-00

16 February 2024

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SECTION 000105 CERTIFICATIONS PAGE

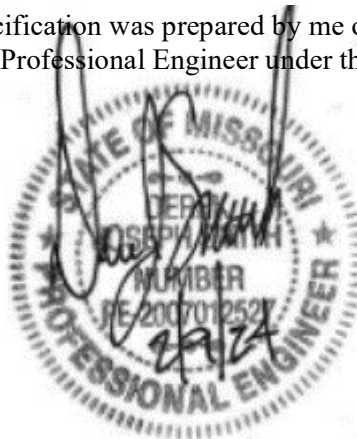
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SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

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 the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Mechanical sleeve seals.
 - 3. Supports and anchorages.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit equipment, riser and piping layout plans, drawn to scale, on which all other electrical, mechanical, plumbing or other systems and building construction are shown and coordinated with each other, using input from installers of the items involved.

1.4 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for Fire-Suppression Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is 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, BCuP Series or BAg1, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12.
- G. Solvent Cements for Joining CPVC Plastic Piping: ASTM F 493.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors.
- M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- N. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using 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.
 - 1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
 - 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

- O. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using 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.
 - 1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Section 078413 "Penetration Firestopping" for materials.
- Q. Verify final equipment locations for roughing-in.
- R. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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.
- E. 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.
- F. 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.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement 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.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

3.3 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division Section 055000 "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor fire-suppression materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.4 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor fire-suppression materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

END OF SECTION 210500

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SECTION 210517 - SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Sleeve-seal systems.
 - 3. Grout.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.

3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.3 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves.
 - 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 (DN 150 and Larger): Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6 (DN 150): Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 (DN 150) and Larger: Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 4. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6 (DN 150).

- b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-pipe sleeves.
- 5. Interior Partitions:
 - a. Piping Smaller Than NPS 6 (DN 150): Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 (DN 150) and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated and rough-brass finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
- 1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 210518

SECTION 210523 - GENERAL-DUTY VALVES FOR WATER-BASED FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Iron butterfly valves with indicators.
 - 2. Check valves.
 - 3. Iron OS&Y gate valves.
 - 4. NRS gate valves.
 - 5. Indicator posts.
 - 6. Trim and drain valves.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

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

2.2 PERFORMANCE REQUIREMENTS

- A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
 - 1. Fire Main Equipment: HAMV - Main Level.
 - a. Indicator Posts, Gate Valve: HCBZ - Level 1.
 - b. Ball Valves, System Control: HLUG - Level 3.
 - c. Butterfly Valves: HLXS - Level 3.
 - d. Check Valves: HMER - Level 3.
 - e. Gate Valves: HMRZ - Level 3.

2. Sprinkler System and Water Spray System Devices: VDGT - Main Level.
 - a. Valves, Trim and Drain: VQGU - Level 1.
 - B. FM Global Approved: Valves shall be listed in its "Approval Guide," under the headings listed below:
 1. Automated Sprinkler Systems:
 - a. Indicator posts.
 - b. Valves.
 - 1) Gate valves.
 - 2) Check valves
 - 3) Miscellaneous valves.
 - C. ASME Compliance:
 1. ASME B1.20.1 for threads for threaded-end valves.
 2. ASME B16.1 for flanges on iron valves.
 3. ASME B31.9 for building services piping valves.
 - D. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
 - E. NFPA Compliance for valves:
 1. Comply with NFPA 13, NFPA 14, NFPA 20, and NFPA 24.
 - F. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher, as required by system pressures.
 - G. Valve Sizes: Same as upstream piping unless otherwise indicated.
 - H. Valve Actuator Types:
 1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
 2. Handwheel: For other than quarter-turn trim and drain valves.
 3. Handlever: For quarter-turn trim and drain valves NPS 2 (DN 50) and smaller.
- 2.3 IRON BUTTERFLY VALVES WITH INDICATORS
- A. Description:
 1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
 2. Minimum Pressure Rating: 175 psig (1200 kPa).
 3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
 4. Seat Material: EPDM.

5. Stem: Stainless steel.
6. Disc: Ductile iron, and EPDM or SBR coated.
7. Actuator: Worm gear.
8. Supervisory Switch: Internal or external.

2.4 CHECK VALVES

A. Description:

1. Standard: UL 312 and FM Global standard for swing check valves, Class Number 1210.
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Type: Single swing check.
4. Body Material: Cast iron, ductile iron, or bronze.
5. Clapper: Bronze, ductile iron, or stainless steel.
6. Clapper Seat: Brass, bronze, or stainless steel.
7. Hinge Shaft: Bronze or stainless steel.
8. Hinge Spring: Stainless steel.
9. End Connections: Flanged, grooved, or threaded.

2.5 IRON OS&Y GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating.
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.

2.6 NRS GATE VALVES

A. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig (1200 kPa).
3. Body and Bonnet Material: Cast or ductile iron.
4. Wedge: Cast or ductile iron with elastomeric coating.
5. Wedge Seat: Cast or ductile iron, or bronze with elastomeric coating
6. Stem: Brass or bronze.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.

2.7 INDICATOR POSTS

A. Description:

1. Standard: UL 789 and FM Global standard for indicator posts.
2. Type: Upright.
3. Base Barrel Material: Cast or ductile iron.
4. Extension Barrel: Cast or ductile iron.
5. Cap: Cast or ductile iron.
6. Operation: Wrench.

2.8 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Description:

- a. Pressure Rating: 175 psig.
- b. Body Design: Two piece.
- c. Body Material: Forged brass or bronze.
- d. Port size: Full or standard.
- e. Seats: PTFE.
- f. Stem: Bronze or stainless steel.
- g. Ball: Chrome-plated brass.
- h. Actuator: Handlever.
- i. End Connections for Valves NPS 1 (DN 25) through NPS 2-1/2 (DN 65): Threaded ends.
- j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2 (DN 32 and DN 65): Grooved ends.

B. Angle Valves:

1. Description:

- a. Pressure Rating: 175 psig.
- b. Body Material: Brass or bronze.
- c. Ends: Threaded.
- d. Stem: Bronze.
- e. Disc: Bronze.
- f. Packing: Asbestos free.
- g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

1. Description:

- a. Pressure Rating: 175 psig
- b. Body Material: Bronze with integral seat and screw-in bonnet.
- c. Ends: Threaded.

- d. Stem: Bronze.
- e. Disc Holder and Nut: Bronze.
- f. Disc Seat: Nitrile.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Comply with requirements in the following Sections for specific valve-installation requirements and applications:
 - 1. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
 - 2. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
 - 3. Section 211316 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.
 - 4. Section 211339 "Foam-Water Systems" for application of valves in AFFF piping.
 - 5. Section 331415 "Site Water Distribution Piping" for application of valves in fire-suppression water-service piping.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply, except from fire-department connections. Install permanent identification signs, indicating portion of system controlled by each valve.
- C. Install double-check valve assembly in each fire-protection water-supply connection.
- D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above the pipe center.
- F. Install valves in position to allow full stem movement.
- G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.

END OF SECTION 210523

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SECTION 210529 - HANGERS AND SUPPORTS FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Thermal hanger-shield inserts.
 - 4. Fastener systems.
 - 5. Equipment supports.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Show fabrication and installation details and include calculations.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer to design trapeze pipe hangers and equipment supports.

- B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7 .
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. NFPA Compliance: Comply with NFPA 13.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: Factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot-dip galvanized.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.3 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly, made from structural-carbon-steel shapes, with NFPA-approved, UL-listed, or FM-approved carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.4 THERMAL HANGER-SHIELD INSERTS

- A. Insulation-Insert Material: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi minimum compressive strength.
- B. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- C. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- D. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: NFPA-approved, UL-listed, or FM-approved threaded-steel stud, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: NFPA-approved, UL-listed, or FM-approved, insert-wedge-type anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

1. Indoor Applications: Zinc-coated or Stainless steel.
2. Outdoor Applications: Stainless steel.

2.6 EQUIPMENT SUPPORTS

- A. Description: NFPA-approved, UL-listed, or FM-approved, welded, shop- or field-fabricated equipment support, made from structural-carbon-steel shapes.

2.7 MATERIALS

- A. Aluminum: ASTM B221 (ASTM B221M).
- B. Carbon Steel: ASTM A1011/A1011M.
- C. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; black and galvanized.
- D. Stainless Steel: ASTM A240/A240M.
- E. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout, suitable for interior and exterior applications.
 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with installation requirements of approvals and listings. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete, after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual. Install in accordance with approvals and listings.
 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.
- E. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- F. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- G. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- H. Install lateral bracing with pipe hangers and supports to prevent swaying.
- I. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, [NPS 2-1/2 (DN 65)] <Insert size> and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
- J. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- K. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.3 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment, and make bearing surface smooth.

- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work.

3.5 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

- A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

- E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use thermal hanger-shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - 3. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 - 5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 - 6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - 9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
- I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- J. Hanger-Rod Attachments: Comply with NFPA requirements.
- K. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 - 2. C-Clamps (MSS Type 23): For structural shapes.
 - 3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

- L. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.
- M. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

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SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, 0.032 inch (0.8 mm) thick, with predrilled 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 (64 by 19 mm).
 - 3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 4. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, minimum 1/16 inch (1.6 mm) thick, with predrilled holes for attachment hardware.
 - 2. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 - 3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - 4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm),

- and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
5. Fasteners: Stainless-steel rivets or self-tapping screws.
 6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- D. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) 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, minimum 1/16 inch (1.6 mm) thick, with predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Red.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.

- C. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm) and proportionately larger lettering for greater viewing distances.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of incompatible primers, paints, and encapsulants, as well as dirt, oil, grease, release agents, and other substances that could impair bond of identification devices.

3.2 LABEL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install or permanently fasten labels on each major item of mechanical equipment.
- D. Locate equipment labels where accessible and visible.
- E. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit a view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

END OF SECTION 210553

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SECTION 221113 - WATER 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 water systems piping for potable water service and fire protection service outside the building.
- B. This Section does not include tapping of utility company water main by utility company and charged directly to Owner.
- C. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Section 312000 Earthwork.
 - 2. Division 21 Sections for fire protection systems inside building.
 - 3. Division 22 Sections for water distribution systems inside building.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure Ratings: Except where otherwise indicated, the following are minimum pressure requirements for water system piping.
 - 1. Underground Piping: 150 psig.

1.4 SUBMITTALS

- A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.
- B. Product data, including pressure rating, rated capacity, and settings of selected models for the following:
 - 1. Ductile Iron Piping.
 - 2. Copper water service tubing, corporation stops, curb stops, and other water service appurtenances.
 - 3. Valves, meters.
 - 4. Fire department connections.
 - 5. Identification materials and devices.

- C. Coordination drawings showing pipe sizes and valves, meter and specialty locations and elevations. Include details of underground structures, connections, anchors, and reaction backing. Show other piping in same trench and clearances from water system piping. Indicate interface and spatial relationship between piping and proximate structures.
- D. Record drawings at Project closeout of installed water system piping and products according to Division 1 Section "Project Closeout."
- E. Test reports specified in "Field Quality Control" Article in Part 3.
- F. Maintenance data for inclusion in "Operating and Maintenance Manual" specified in Division 1 Section "Project Closeout." Include data for the following:
 - 1. Valves.
 - 2. Water Meters.

1.5 QUALITY ASSURANCE

- A. Comply with requirements of the City of Lee's Summit, Missouri.
- B. Comply with standards of the City of Lee's Summit, Missouri for fire protection systems. Include materials, hose threads, installation, and testing.
- C. Comply with standards of the City of Lee's Summit, Missouri for potable water piping and plumbing systems. Include materials, installation, testing, and disinfection.
- D. Provide listing/approval stamp, label, or other marking on equipment made to specified standards.
- E. Listing and Labeling: Provide equipment and accessories that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in "National Electrical Code," Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- F. Product Options: Water systems specialties and accessories are based on specific types, manufacturers, and models indicated. Components by other manufacturers but having equal performance characteristics may be considered, provided deviations in dimensions, operation, and other characteristics do not change design concept or intended performance as judged by Architect and the Owner's Representative. The burden of proof of equality of products is on Contractor. Refer to Division 1 Section "Product Substitutions."

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Preparation for Transport: Prepare valves, including fire hydrants, for shipping as follows:
 - 1. Ensure that valves are dry and internally protected against rust and corrosion.
 - 2. Protect valves against damage to threaded ends, flange faces, and weld ends.
 - 3. Set valves in best position for handling. Set valves closed to prevent rattling.

- B. Storage: Use the following precautions for valves, including fire hydrants, during storage:
 - 1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
 - 2. Protect valves from weather. Store valves indoors and maintain temperature higher than ambient dew point temperature. Support valves off ground or pavement in watertight enclosures when outdoor storage is necessary.
- C. Handling: Use sling to handle valves and fire hydrants whose size requires handling by crane or lift. Rig valves to avoid damage to exposed valve parts. Do not use handwheels or stems as lifting or rigging points.
- D. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- E. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.
- F. Protect flanges, fittings, and piping specialties from moisture and dirt.
- G. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Utility locates shall be scheduled through Owner's Representative at least 72 hours in advance. Contractor shall contact Missouri One Call at 1-800-DIG-RITE for utility locations.
- B. Verify that water system piping may be installed in compliance with original design and referenced standards.
- C. Site Information: Reports on subsurface condition investigations made during the design of the Project are available for informational purposes only; data in reports are not intended as representations or warranties of accuracy or continuity of conditions (between soil borings). Owner or the Owner's Representative assumes no responsibility for interpretations or conclusions drawn from this information.

1.8 SEQUENCING AND SCHEDULING

- A. Coordinate all connections to the water main and any new construction with the Metropolitan Community College.
- B. Coordinate with pipe materials, sizes, entry locations, and pressure requirements of building fire protection systems piping.
- C. Coordinate with pipe materials, sizes, entry locations, and pressure requirements of building water distribution systems piping.

- D. Coordinate with other utility work.

PART 2 - PRODUCTS

2.1 PIPES AND TUBES

- A. Refer to Part 3 Article "Piping Applications" for identification of systems where pipe and tube materials specified below are used.
- B. Ductile Iron Pipe shall comply with Section 3900 of the Lee's Summit, Missouri Standard Specifications.
- C. Copper Tube: ASTM B 88, Type k (ASTM B 88M, Types A and B), seamless water tube, annealed temper.
 - 1. Gaskets: ASTM F 477, elastomeric seal.
- D. Ductile-Iron Pipe Fittings:
 - 1. 4 Inches to 24 Inches: AWWA C151; Mechanical Joint Pipe; 150 psi working pressure; Minimum Thickness Class 52; with integrally cast flanged bell, cast iron gland and rubber gasket.
 - 2. Lining: Standard cement lining with asphalt coating.
 - 3. Encasement: AWWA C105, polyethylene film.

2.2 PIPE AND TUBE FITTINGS

- A. Refer to Part 3 Article "Piping Applications" for identification of systems where pipe and tube fitting materials specified below are used.
- B. Polyethylene Encasement: AWWA C105, Type III – High Density Class C Grade p-33 PE film, 4-mil minimum thickness, tube.
- C. Fittings for copper water service shall be ANSI B16.22 wrought copper.
- D. Ductile-Iron Pipe Fittings:
 - 1. 4 Inches to 24 Inches: AWWA C153, 350-psi pressure rating.
 - 2. Lining: Standard cement lining with asphalt coating.
 - 3. Encasement: AWWA C105, polyethylene film.
- E. Fitting Restraint:
 - 1. Mechanical joint: AWWA C111. Provide retainer type packing glands with rubber gasket, UL listed and conforming to Uni-B-13-92. EBAA Megalug 2000 PV or approved equal.
 - 2. Rods: ¾" stainless steel all thread rods.

2.3 JOINING MATERIALS

- A. Refer to Part 3 Article "Piping Applications" for identification of systems where joining materials specified below are used.
- B. Ductile-Iron Fittings: The following materials apply:
 - 1. Mechanical Joints: AWWA C111 ductile-iron glands, stainless steel bolts and nuts, and rubber gaskets. All mechanical joints shall have the following:
 - a. Series 2000PV Mega-Lug Retaining Gland System for PVC Pipe, EBAA Iron, Inc., or approved equal.
- C. Solder Filler Metal: ASTM B 32, Alloy Sn95; tin (approximately 95 percent), silver (approximately 4.5 percent). Domestic water pipe shall use lead free solder.
- D. Pipe Couplings: Iron-body sleeve assembly, fabricated to match outside diameters of pipes to be joined.
 - 1. Sleeve: ASTM A 126, Class B, gray iron.
 - 2. Followers: ASTM A 47, Grade 32510, or ASTM A 536 ductile iron.
 - 3. Gaskets: Rubber.
 - 4. Bolts and Nuts: AWWA C111.
 - 5. Finish: Enamel paint.
 - 6. Encasement: AWWA C105, polyethylene film tube or sheet.

2.4 PIPING SPECIALTIES

- A. Dielectric Fittings: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and corrosion.
 - 1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld-neck end types and matching piping system materials.
 - 2. Dielectric Unions: Factory-fabricated union assembly, designed for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C). Include insulating material isolating dissimilar metals and ends with inside threads according to ASME B1.20.1.
 - 3. Dielectric Flanges: Factory-fabricated companion-flange assembly, for 150-psig (1035-kPa) or 300-psig (2070-kPa) minimum pressure to suit system pressures.
 - 4. Dielectric-Flange Insulation Kits: Field-assembled companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - a. Provide separate companion flanges and steel bolts and nuts for 150-psig (1035-kPa) or 300-psig (2070-kPa) minimum working pressure to suit system pressures.
 - 5. Dielectric Couplings: Galvanized-steel couplings having inert and noncorrosive thermoplastic lining, with threaded ends and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

6. Dielectric Nipples: Electroplated steel nipples having inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig (2070-kPa) working pressure at 225 deg F (107 deg C).

2.5 VALVES

- A. Valves shall comply with Section 3900 of the Lee's Summit, Missouri Standard Specifications.

2.6 WATER METERS

- A. Water meters shall be as specified by the Metropolitan Community College.

2.7 ACCESSORIES AND SPECIALTIES

- A. For Copper service-line branch connection (i.e. Irrigation system), provide ductile iron tee on the service main and install ductile iron gate-valve on the branch followed by mechanical tapped plug or approved compatible reducer on the branch line.
- B. Valve Boxes shall comply with Section 3900 of the Lee's Summit, Missouri Standard Specifications.
- C. Indicator Posts: UL 789, FM-approved, horizontal, wall-type, cast-iron body with operating wrench, extension rod, and cast-iron barrel.

2.8 CONCRETE VAULTS

- A. Description: Precast, reinforced-concrete vault, designed for A-16 load designation according to ASTM C 857 and made according to ASTM C 858.

2.9 ANCHORAGES

- A. Clamps, Straps, and Washers: ASTM A 506, steel.
- B. Rods: ASTM A 575, steel.
- C. Rod Couplings: ASTM A 197, malleable iron.
- D. Bolts: ASTM A 307, steel.
- E. Cast-Iron Washers: ASTM A 126, gray iron.
- F. Concrete Reaction Backing: Portland cement concrete mix, 3,000 psi.
 1. Cement: ASTM C 150, Type I.
 2. Fine Aggregate: ASTM C 33, sand.
 3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable.

2.10 IDENTIFICATION

- A. Plastic Underground Warning Tapes: Polyethylene plastic tape, 6 inches (150 mm) wide by 4 mils (0.1 mm) thick, solid blue in color with continuously printed caption in black letters "CAUTION - WATER LINE BURIED BELOW."

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earthwork."

3.2 SERVICE ENTRANCE PIPING

- A. Extend water system piping and connect to water supply source and building water distribution and fire protection systems at outside face of the building wall in locations and pipe sizes indicated.
 1. Terminate water system piping at building wall until building water systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building water systems when those systems are installed.
- B. Water distribution systems and fire protection systems are specified in Division 21 and 22 Sections. Sleeves and mechanical sleeve seals are specified in Division 22 Sections
- C. Install restrained joints for buried piping within 5 feet of building. Use restrained-joint pipe and fittings, anchors, tie-rods and clamps, and other supports at vertical and horizontal offsets.

3.3 PIPING APPLICATIONS

- A. Refer to Part 2 of this Section for detailed specifications for pipe and fittings products listed below. Use pipe, tube, fittings, and joining methods according to the following applications. Piping in pits and inside building may be joined with flanges or couplings, instead of joints indicated, for grooved-end AWWA-size piping.
- B. Use pipe, tube, fittings, and joining methods according to following applications.
 1. 2 Inches and smaller: Copper tube, Type K, ASTM B88, installed according to AWWA C800.
 2. 4 - 8 Inches and larger: ductile Iron Pipe, AWWA C600.

3.4 VALVE APPLICATIONS

- A. The following requirements apply:
 - 1. Buried Valves 3 Inches and Larger: AWWA, gate valves, non-rising stem, with valve box, set in a concrete surround.

3.5 JOINT CONSTRUCTION

- A. Copper Tube and Fittings, Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter "The Soldering of Pipe and Tube."
- B. Ductile Iron Pipe joints shall comply with Section 3900 of the Lee's Summit, Missouri Standard Specifications.
- C. Dissimilar Materials Piping Joints: Construct joints using adapters that are compatible with both piping materials, outside diameters, and system working pressure. Refer to Article 3.6, "Piping Systems - Common Requirements" for joining piping of dissimilar metals.

3.6 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. General Locations and Arrangements: Install piping at locations indicated in the plans except where deviations to layout are approved on coordination drawings.
- B. Install piping at indicated slope.
- C. Install components having pressure rating equal to or greater than system operating pressure.
- D. Install piping free of sags and bends.
- E. Locate groups of pipes parallel to each other, spaced to permit valve servicing.
- F. Install fittings for changes in direction and branch connections.
- G. Piping Connections: Except as otherwise indicated, make piping connections as specified below.
 - 1. Install dielectric fittings to connect piping of dissimilar metals.

3.7 PIPING INSTALLATION

- A. Water Main Connection: Arrange for tap in water main, of size and in location indicated on the drawings. Coordinate and tap with the Metropolitan Community College. Cost to be borne by the Contractor.
- B. Ductile Iron Pipe installation shall comply with Section 3900 of the Lee's Summit, Missouri Standard Specifications.
 - 1. Bury piping with depth of cover over top at least 42 inches

- C. Install copper tube and wrought-copper fittings according to CDA No. 404/0 "Copper Tube Handbook."

3.8 ANCHORAGE INSTALLATION

- A. Anchorages: Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches. Include anchorages for the following piping systems:
 - 1. All mechanical joints shall have the following type of retaining gland system:
 - a. Series 2000PV Mega-Lug Retaining Gland System for PVC Pipe, EBAA Iron Inc. or approved equal.
 - 2. At changes in direction, concrete thrust blocks or rodding, in addition to retaining glands, shall be required.
- B. Apply an acceptable corrosion-retarding material to surfaces of installed ferrous anchorage devices.

3.9 VALVE INSTALLATION

- A. Valve Installation shall comply with Section 3900 of the Lee's Summit, Missouri Standard Specifications.

3.10 WATER METER INSTALLATION

- A. Install precast concrete vaults according to ASTM C 891.
- B. Connect drain outlet to storm drainage piping. Refer to Division 33 Section "Storm Drainage."

3.11 IDENTIFICATION INSTALLATION

- A. Install continuous plastic underground warning tape during backfilling of trench for underground water piping. Locate 24 inches above the water pipe.

3.12 FIELD QUALITY CONTROL

- A. Piping Tests: Conduct piping tests before joints are covered and after anchorage is in place. Fill pipeline 24 hours prior to testing and apply test pressure to stabilize system. Use only potable water.
- B. Hydrostatic Tests: Test at not less than 1-1/2 times working pressure, or 100 psig, whichever is greater, for a minimum of 4 hours.
 - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 1 hour; decrease to 0 psig. Slowly increase again to test pressure and

hold for 1 more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within above limits.

3.13 WATERLINE DISINFECTION

- A. Water line disinfection shall be performed in accordance with AWWA C651 and Section 3900 of the Lee's Summit, Missouri Standard Specifications. Not more than 4000 feet of water main shall be installed without disinfecting.
- B. After installation the entire waterline shall be completely filled and flushed to eliminate air and remove any foreign material in the line.
- C. The Contractor shall chlorinate the line by the "continuous-feed method" or "slug-method" according to AWWA C651 and the Water Services Department Standards and Specifications. Operate all valves and hydrants in order to disinfect appurtenances.
- D. After the appropriate retention period has elapsed, the chlorinated water shall be flushed from the water line until the chlorine measurements of the water leaving the tested line are no higher than that of the existing system. Test water flushed from the line shall be disposed of in an environmentally safe manner and shall not be discharged into the sanitary sewer.
- E. The Contractor shall coordinate disinfect and testing and bacteriological testing with the Water Services Department.
- F. Prepare reports for purging and disinfecting activities.

END OF SECTION 211113

SECTION 211313 - WET-PIPE FIRE-SUPPRESSION SPRINKLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, fittings, and specialties.
 - 2. Fire-protection valves.
 - 3. Fire-department connections.
 - 4. Sprinklers.
 - 5. Excess-pressure pumps.
 - 6. Alarm devices.
 - 7. Pressure gages.

1.3 SYSTEM DESCRIPTIONS

- A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.4 PERFORMANCE REQUIREMENTS

- A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
- B. Delegated Design: Design sprinkler systems, including comprehensive engineering analysis by qualified professional engineer, using performance requirements and design criteria indicated. The design and installation shall comply with the requirements of the authorities having jurisdiction, NFPA 13, NFPA 14, UL, FM Global, and the owner's insurance underwriter's requirements.
 - 1. Obtain fire-hydrant flow test records that indicate the following conditions:
 - a) Date
 - b) Time
 - c) Location of Residual Fire Hydrant
 - d) Location of Flow Fire Hydrant

- e) Static Pressure at Residual Fire Hydrant
- f) Measured Flow at Flow Fire Hydrant
- g) Residual Pressure at Residual Fire Hydrant

C. Sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: Greater of 10 percent or 10-psi, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:
 - a) Educational: Light Hazard
 - b) Building Service Areas: Ordinary Hazard, Group 1.
 - c) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - d) Elevator Machine Room and Hoistway: Ordinary Hazard, Group 1
 - e) General Storage Areas: Ordinary Hazard, Group 1.
 - f) Machine Shops: Ordinary Hazard, Group 2.
 - g) Mechanical Equipment Rooms: Ordinary Hazard, Group.
 - h) Office and Public Areas: Light Hazard.
 - i) Repair Garages: Ordinary Hazard, Group 2.
3. Minimum Density for Automatic-Sprinkler Piping Design:
 - a) Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
 - b) Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
 - c) Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.
4. Maximum Protection Area per Sprinkler:
 - a) Per the requirements of authorities having jurisdiction.
 - b) According to NFPA 13 recommendations unless otherwise indicated.
 - c) Per UL listing
5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
 - a) Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
 - b) Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.
 - c) Extra-Hazard Occupancies: 500 gpm (31.5 L/s) for 90 to 120 minutes.

D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13.

1.5 SUBMITTALS

- A. Shop Drawings: For wet-pipe sprinkler systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.
- B. Delegated-Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional responsible for their preparation.
- C. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Domestic plumbing piping.
 2. HVAC equipment and ductwork in ceiling space
 3. HVAC hydronic piping.
 4. Items penetrating finished ceiling include the following:
 - a) Lighting fixtures.
 - b) Air outlets and inlets.
 5. Coordinate location of exposed piping with architect, engineer and owner prior to installation. Highlight all exposed piping on shop drawings. No additional compensation will be approved for relocation of piping in areas where sprinkler piping is exposed if not previously coordinated. Any exposed piping shall be run perpendicular to ceilings, walls, structural elements, etc. and shall be run neat and tight to structure where possible.
- D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13 and NFPA 14, that have been approved by authorities having jurisdiction, including hydraulic calculations.
 1. Sprinklers shall be referred to on drawings, submittals and other documentation, by the sprinkler identification or Model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.
- E. Fire-hydrant flow test report.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a) Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.
- B. Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

- C. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 1. All castings used for couplings housings, fittings, or valve and specialty bodies shall be date stamped for quality assurance and traceability.
- 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. Standards: All sprinkler system design, materials, equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13, "Installation of Sprinkler Systems."
 - 2. NFPA 14, "Standard for the Installation of Standpipe and Hose Systems"
 - 3. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."
 - 4. International Fire Code
 - 5. Local jurisdiction requirements

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 STEEL PIPE AND FITTINGS

- A. Standard-Weight, Black Steel Pipe: ASTM A53/A53M, Type E. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 30, Black Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
- C. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
- D. Grooved-Joint, Steel-Pipe Appurtenances:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company.
 - b) Anvil International, Inc.
 - c) Corcoran Piping System Co.
 2. Pressure Rating: 250 psig (1725 kPa) minimum.
 3. Uncoated, Grooved-End Fittings for Steel Piping: ASTM A 536, ductile-iron casting; with dimensions matching steel pipe. In applicable sizes, short-pattern, with flow equal to standard pattern fittings. Basis of Design: Victaulic FireLock.
 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213, rigid pattern with offsetting angle-pattern bolt pads, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and ASTM A449 compliant bolts and nuts.
 - a) Rigid Type: Housings cast with offsetting, angle-pattern, bolt pads to provide system rigidity and support and hanging in accordance with NFPA-13, fully installed at visual pad-to-pad offset contact. (Couplings that require exact gapping at specific torque ratings are not permitted.). Installation-Ready for complete installation without field disassembly. Basis of Design: Victaulic Style 009N and 107N.
 - b) Flexible Type: For use in locations where vibration attenuation and stress relief are required: Basis of Design: Victaulic Installation-Ready Style 004 or Style 75.
 5. Installation-Ready™ fittings for Schedule [40] [10] grooved end steel piping in fire protection applications sizes NPS 1-¼ thru 2½ (DN 32 thru DN 65). Fittings shall consist of a ductile iron housing conforming to ASTM A-536, Grade 65-45-12, with Installation-Ready™ ends, [orange enamel coated] [red enamel coated] [galvanized]. Fittings complete with prelubricated Grade “E” EPDM Type ‘A’ gasket; and ASTM A449 electroplated steel bolts and nuts. System shall be UL listed for a working pressure of 300 psi (2065 kPa) and FM approved for working pressure 365 psi (2517kPa).
 - a) Victaulic FireLock IGS System with “Installation-Ready™ fittings and couplings may be used for NPS 1 (DN 25) Schedule 10 and Schedule 40 carbon steel pipe in fire protection applications. System rated for a working pressure to 365 psi (2517 kPa). IGS “Innovative Groove System” groove with shortened “A” dimension and tapered groove backside for ease of installation.
- E. Stainless Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig (1200-kPa) pressure rating with stainless steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Vic-Press for Schedule 10S Pipe.

2.3 STEEL PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free.
 - 1. Class 125, Cast-Iron Flat-Face Flanges: Full-face gaskets.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- D. Grooved Joint Lubricants: Lubricate gasket in accordance with the manufacturer's published instructions with lubricant approved for the gasket elastomer and fluid media. Basis of Design: Victaulic Vic-Lube.

2.4 LISTED FIRE-PROTECTION VALVES

- A. General Requirements:
 - 1. Valves shall be UL listed or FM approved.
 - 2. Minimum Pressure Rating: 250 psig (1725 kPa).
- B. Check Valves:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 717.
 - b) NIBCO, INC.
 - c) Viking Corporation.
 - d) Watts Water Technologies, Inc.
 - 2. Standard: UL 312.
 - 3. Pressure Rating: 250 psig (1725 kPa) minimum.
 - 4. Type: Spring-assisted swing check.
 - 5. Body Material: Cast ductile iron.
 - 6. Installation: Vertical or horizontal.
 - 7. End Connections: Flanged or grooved.
- C. Bronze OS&Y Gate Valves:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Crane Co.; Crane Valve Group; Crane Valves.
 - b) Crane Co.; Crane Valve Group; Stockham Division.

- c) Milwaukee Valve Company.
- d) NIBCO INC.
- e) United Brass Works, Inc.

- 2. Standard: UL 262.
- 3. Pressure Rating: 175 psig (1200 kPa).
- 4. Body Material: Bronze.
- 5. End Connections: Threaded.

D. Iron OS&Y Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 771.
 - b) American Valve, Inc.
 - c) NIBCO, INC.
 - d) Watts Water Technologies, Inc.
- 2. Standard: UL 262.
- 3. Pressure Rating: 250 psig (1725 kPa) minimum.
- 4. Body Material: Cast or ductile iron.
- 5. End Connections: Flanged or grooved.

E. Indicating-Type Butterfly Valves:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 728 (ball) and 705 (butterfly).
 - b) Fivalco, Inc.
 - c) NIBCO, INC.
- 2. Standard: UL 1091.
- 3. Pressure Rating: 250 psig (1725 kPa) minimum.
- 4. Actuator: Weatherproof housing with handwheel and supervisory switches.
- 5. Valves NPS 2 (DN 50) and Smaller:
 - a) Valve Type: Ball.
 - b) Body Material: Bronze or brass.
 - c) End Connections: Threaded or grooved ends.
- 6. Valves NPS 2-1/2 (DN 65) and Larger:
 - a) Valve Type: Butterfly.
 - b) Body Material: Cast or ductile iron.
 - c) Seat: Pressure-responsive elastomer.

- d) Stem: Stainless steel; offset from the disc centerline to provide complete 360-degree circumferential seating.
- e) End Connections: Flanged, grooved, or wafer.

2.5 TRIM AND DRAIN VALVES

A. General Requirements:

- 1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
- 2. Minimum Pressure Rating: 175 psig (1200 kPa).

B. Ball Valves:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company.
 - b) NIBCO, INC.
 - c) Potter Roemer.
 - d) Watts Water Technologies, Inc.

2.6 SPECIALTY VALVES

A. General Requirements:

- 1. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
- 2. Minimum Pressure Rating: 250 psig (1725 kPa).
- 3. Body Material: Cast or ductile iron.
- 4. Size: Same as connected piping.
- 5. End Connections: Flanged or grooved.

B. Alarm Valves:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 751.
 - b) Reliable Automatic Sprinkler Co., Inc.
 - c) Viking Corporation.
- 2. Standard: UL 193.
- 3. Design: For vertical installation.
- 4. Valve internal components shall be replaceable without removal of valve from installed position.

5. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, and fill-line attachment with strainer.
6. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
7. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

C. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) AFAC Inc.
 - b) Reliable Automatic Sprinkler Co., Inc.
 - c) Tyco Fire & Building Products LP.
2. Standard: UL 1726.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4 (DN 20).
6. End Connections: Threaded.

2.7 FIRE-DEPARTMENT CONNECTIONS

A. Flush-Type, Fire-Department Connection: Provide a fire-department connection of the size and type required by the local authority.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) AFAC Inc.
 - b) Elkhart Brass Mfg. Company, Inc.
 - c) GMR International Equipment Corporation.
 - d) Guardian Fire Equipment, Inc.
 - e) Potter Roemer.
2. Standard: UL 405.
3. Type: Flush, for wall mounting.
4. Pressure Rating: 175 psig (1200 kPa) minimum.
5. Body Material: Corrosion-resistant metal.
6. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
7. Caps: Brass, lugged type, with gasket and chain.
8. Escutcheon Plate: Rectangular, brass, wall type.
9. Outlet: With pipe threads.
10. Body Style: Horizontal.
11. Number of Inlets: Two.
12. Escutcheon Plate Marking: Similar to "AUTO SPKR."

13. Finish: Polished chrome plated.
14. Outlet Size: NPS 4 (DN 100).
15. At the low point near each fire department connection, install a 90-degree elbow with drain connection to allow for localized system drainage to prevent freezing. Basis of Design: Victaulic #10-DR.

2.8 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Style 920 / 920N.
 - b) Anvil International, Inc.
 - c) National Fittings, Inc.
2. Standard: UL 213.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Ductile-iron housing with EPDM seals and ASTM A449 compliant bolts and nuts.
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 747.
 - b) AGF Manufacturing Inc.
 - c) Reliable Automatic Sprinkler Co., Inc.
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved ends.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Elkhart Brass Mfg. Company, Inc.
 - b) Fire-End & Croker Corporation.
 - c) Potter Roemer.
2. Standard: UL 199.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 720 TestMaster II.
 - b) AGF Manufacturing Inc.
 - c) Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" listing or "Approval Guide," published by FM Global, listing.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast-bronze or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved ends.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) CECA, LLC.
 - b) Corcoran Piping System Co.
 - c) Merit Manufacturing; a division of Anvil International, Inc.
2. Standard: UL 1474.
3. Pressure Rating: 250 psig (1725 kPa) minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible, Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Vic-Flex.
 - b) Fivalco Inc.
 - c) FlexHead Industries, Inc.
 - d) Gateway Tubing, Inc.
 - e) Victaulic
2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with open-gate bracket for connection to ceiling grid and zinc plated steel Male threaded nipple or Victaulic FireLock IGS Groove Style 108 coupling for connection to branch-line piping.
4. Pressure Rating: 175 psig (1200 kPa) minimum.
5. Size: Same as connected piping, for sprinkler.
6. Union joints shall be provided for ease of installation.
7. Bracket: The flexible drop shall attach to the ceiling grid using a one-piece open gate bracket. The bracket shall allow installation before the ceiling tile is in place.

2.9 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company.
 - b) Reliable Automatic Sprinkler Co., Inc.
 - c) Viking Corporation.
- B. General Requirements: Glass bulb type, with hex shaped wrench boss integrally cast into the sprinkler body to reduce the risk of damage during installation.
 1. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide".
 2. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.
 3. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.
 4. Pressure Rating for High-Pressure Automatic Sprinklers: 250 psig (1725 kPa) minimum.
- C. Automatic Sprinklers with Heat-Responsive Element:
 1. Nonresidential Applications: UL 199.
 2. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- D. Sprinkler Finishes:

1. Chrome plated – in unoccupied locations (mechanical rooms, storage rooms, etc.)
2. Bronze.
3. Painted – white – in occupied, visible locations.

E. Special Coatings:

1. Wax.
2. Lead.
3. Corrosion-resistant paint.

F. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Plastic, one piece, flat. Finish color to match ceiling.
2. Sidewall Mounting: Plastic, white finish, one piece, flat.

G. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Reliable Automatic Sprinkler Co., Inc.
 - b) Victaulic Company.
 - c) Viking Corporation.
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

H. Escutcheons and guards shall be listed, supplied, and approved for use with the sprinkler by the sprinkler manufacturer.

I. Wrenches shall be provided by the sprinkler manufacturer that directly engage the hex-shaped wrench boss integrally cast in the sprinkler body.

2.10 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Victaulic Company; Series 760.
 - b) Globe Fire Sprinkler Corporation.
 - c) Viking Corporation.

2. Standard: UL 753.
3. Type: Mechanically operated, with Pelton wheel.
4. Alarm Gong: Cast aluminum with red-enamel factory finish.
5. Size: 10-inch (250-mm) diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4 (DN 20).
8. Outlet: NPS 1 (DN 25) drain connection.

C. Electrically Operated Notification Appliances:

1. Electric Bell:
 - a) Standard: UL 464.
 - b) Type: Vibrating, metal alarm bell.
 - c) Size: 6-inch (150-mm) minimum- diameter.
 - d) Voltage: 120 V ac, 60 Hz, 1 phase.
 - e) Finish: Red-enamel or polyester powder-coat factory finish, suitable for outdoor use with approved and listed weatherproof backbox.
2. Strobe/Horn:
 - a) Standard: UL 464.
 - b) Tone: Selectable, steady, Temporal-3 (T-3) in accordance with ISO 8201 and ANSI/ASA S3.41, 2400 Hz, electromechanical, broadband.
 - c) Voltage: 120 V ac, 60 Hz.
 - d) Effective Intensity: 110 cd.
 - e) Finish: Red, suitable for outdoor use with approved and listed weatherproof backbox. White letters on housing identifying device as for "Fire."
 - f) Sign, Integrated: Mount between backbox and strobe/horn with text visible on both sides, above and below strobe/horn. Housing to be shaped to cover surface-mounted weatherproof backbox. Sign is to consist of white lettering on red plastic identifying it as a "Sprinkler Fire Alarm" and instructing viewers to call 911, police, or fire department.

D. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) ADT Security Services, Inc.
 - b) McDonnell & Miller; ITT Industries.
 - c) Potter Electric Signal Company.
 - d) System Sensor; a Honeywell company.
 - e) Viking Corporation.
 - f) Watts Industries (Canada) Inc.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.

4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.
6. Pressure Rating: 250 psig (1725 kPa).
7. Design Installation: Horizontal or vertical.

E. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a) Fire-Lite Alarms, Inc.; a Honeywell company.
 - b) Kennedy Valve; a division of McWane, Inc.
 - c) Potter Electric Signal Company.
 - d) System Sensor; a Honeywell company.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.

2.11 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AMETEK; U.S. Gauge Division.
 2. Ashcroft, Inc.
 3. Brecco Corporation.
 4. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.
- D. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum.
- E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.
- F. Air System Piping Gage: Include retard feature and "AIR" or "AIR/WATER" label on dial face.

2.12 GROUT

- A. Standard: ASTM C 1107, Grade B, posthardening and volume adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink, and recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 1. All exposed sprinkler piping shall be run neat and symmetrical with regard to other construction and shall be approved by the architect.
 - 2. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- B. Piping Standard: Comply with requirements for installation of sprinkler piping in NFPA 13.
- C. Install seismic restraints on piping. Comply with requirements for seismic-restraint device materials and installation in NFPA 13.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
- F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
- G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

- K. Install alarm devices in piping systems.
- L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.
- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- N. Fill sprinkler system piping with water.
- O. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Coordinate with the electrical contractor.

3.2 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
- I. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints and in accordance with the manufacturer's latest published instructions. Gaskets shall be molded and produced by the grooved coupling manufacturer. Grooved ends shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove.
 1. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products.
 2. The factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.

3.3 VALVE AND SPECIALTIES INSTALLATION

- A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- D. Specialty Valves:
 1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
 2. Alarm Valves: Include bypass check valve and retarding chamber drain-line connection.

3.4 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in the center of the short dimension of acoustical ceiling panels.
- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
- C. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.
- D. Do not install sprinklers that have been dropped, damaged, show a visible loss of fluid, or a cracked bulb.

- E. The sprinkler bulb protector shall be removable by hand, without tools or devices that may damage the bulb.

3.5 FIRE-DEPARTMENT CONNECTION INSTALLATION

- A. Install wall-type, fire-department connections.
- B. Install automatic (ball drip) drain valve at each check valve for fire-department connection.

3.6 SLEEVE INSTALLATION

- A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
- B. Sleeves are not required for core-drilled holes.

3.7 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Electrical Identification."

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 4. Energize circuits to electrical equipment and devices.
 - 5. Start and run excess-pressure pumps.
 - 6. Coordinate with fire-alarm tests. Operate as required.
 - 7. Coordinate with fire-pump tests. Operate as required.
 - 8. Verify that equipment hose threads are same as local fire-department equipment.
- C. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.9 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.

3.10 PIPING SCHEDULE

- A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends, grooved-end-pipe couplings; and grooved joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Wet-pipe sprinkler system, NPS 2 and smaller, shall be the following:
 - 1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be one of the following:
 - 1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight or Schedule 30, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 3. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

3.11 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Ceilings: Concealed pendent sprinklers.
 - 3. Wall Mounting: Concealed sidewall sprinklers.
 - 4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as required.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted cover plate, color to match adjacent surfaces.
 - 2. Flush Sprinklers: Bright chrome, with painted white escutcheon.

3. Recessed Sprinklers: Bright chrome, with painted escutcheon, color to match ceiling.
4. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313

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SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

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 the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Dielectric fittings.
 - 3. Grout.
 - 4. Equipment installation requirements common to equipment sections.
 - 5. Concrete bases.
 - 6. Supports and anchorages.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit 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. Pipe installation (sanitary, water, storm, gas, etc.), indicating coordination with general construction, building components including structure, HVAC equipment and ductwork, sprinkler piping, electrical panels, service and conduits, cable trays, and other building services. Indicate proposed changes to pipe layout.
 - 2. Suspended ceiling components.
 - 3. Size and location of access to concealed valves and equipment.
 - 4. Penetrations of smoke barriers and fire-rated construction.
- B. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.4 DEFINITIONS

- A. Finished Spaces: Spaces other than plumbing and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and plumbing equipment rooms.

- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Characteristics of Plumbing Material and Equipment: Material and Equipment of equal performance and similar characteristics to the basis of design material and equipment specified in the plans and in other sections of these specifications may be furnished provided such proposed equipment is approved by the engineer. The contractor is responsible for guaranteeing that the proposed material or equipment is equal in performance to the specified material or equipment under all operating conditions. All connecting electrical services, circuit breakers, and conduit sizes are to be appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements. All costs associated with the substitution of materials and equipment or costs of replacing substituted equipment or material with material or equipment with operating characteristics equal to the specified material or equipment shall be borne by the substituting contractor.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.

- B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is 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, BCuP Series or BAg1, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12.
- G. Solvent Cements for Joining Plastic Piping:
 - 1. ABS Piping: ASTM D 2235.
 - 2. CPVC Piping: ASTM F 493.
 - 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - 4. PVC to ABS Piping Transition: ASTM D 3138.

2.3 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
- E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.4 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 PLUMBING DEMOLITION

- A. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 3. Fixtures and Equipment to Be Removed: Disconnect and cap services and remove fixture or equipment.
 4. Fixtures and Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store fixture or equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 5. Fixtures or Equipment to Be Removed and Salvaged: Disconnect and cap services and remove fixture or equipment and deliver to Owner.
- B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 INSTALLATION – COMMON REQUIREMENTS

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. 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.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise. Piping to be exposed in occupied areas is to be installed as high as possible (tight to

roof or floor deck above, offsetting down below structural elements), and tight to and stacked along walls.

- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors.
- M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- N. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
- O. Verify final equipment locations for roughing-in.
- P. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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.
- E. 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.

- F. 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.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement 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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, 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.
 - 5. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
- L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.5 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.7 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in other portions of these specifications.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor plumbing materials and equipment.
- B. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.10 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 220500

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.

- a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Cast-iron wall sleeves, or Galvanized-steel wall sleeves.
 - 2. Exterior Concrete Walls below Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 4. Concrete Slabs above Grade:
 - a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
 - 5. Interior Partitions:
 - a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.

END OF SECTION 220517

SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
- b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
- c. Insulated Piping: One-piece, stamped-steel type.
- d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
- e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
- f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
- g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
- h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
- i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
- j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
- k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.

- C. Install floor plates for piping penetrations of equipment-room floors.

- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Liquid-in-glass thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gages.
 - 4. Gage attachments.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Trerice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.

2. Standard: ASME B40.200.
3. Case: Cast aluminum; 7-inch (178-mm) nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F (deg C).
7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

2.3 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMETEK, Inc.; U.S. Gauge.
 - b. Ashcroft Inc.
 - c. Ernst Flow Industries.
 - d. Flo Fab Inc.
 - e. Marsh Bellofram.
 - f. Miljoco Corporation.
 - g. Noshok.

- h. Palmer Wahl Instrumentation Group.
 - i. REOTEMP Instrument Corporation.
 - j. Tel-Tru Manufacturing Company.
 - k. Terice, H. O. Co.
 - l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - m. Weiss Instruments, Inc.
 - n. WIKA Instrument Corporation - USA.
 - o. Winters Instruments - U.S.
- 2. Standard: ASME B40.100.
 - 3. Case: Sealed cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
 - 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 6. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 - 8. Pointer: Dark-colored metal.
 - 9. Window: Glass or plastic.
 - 10. Ring: Metal.
 - 11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range or better.

2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston or porous-metal-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15) ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

G. Install thermometers in the following locations:

1. Outlet of each water heater.
2. Hot water recirculation piping near the water heater.
3. Inlets and outlets of each domestic water heat exchanger.
4. Inlet and outlet of each domestic hot-water storage tank.

H. Install pressure gages in the following locations:

1. Building water service entrance into building.
2. Inlet and outlet of each pressure-reducing valve.
3. Suction and discharge of each domestic water pump.

I. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

J. Adjust faces of meters and gages to proper angle for best visibility.

3.2 THERMOMETER SCHEDULE

A. Thermometers shall be:

1. Liquid-filled, bimetallic-actuated type.

B. Thermometer stems shall be of length to match thermowell insertion length.

3.3 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F (Minus 20 to plus 50 deg C).

B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F.

3.4 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Water Service Piping: 0 to 100 psi (0 to 600 kPa)

END OF SECTION 220519

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Bronze ball valves.
 - 2. Iron, single-flange butterfly valves.
 - 3. Bronze swing check valves.
 - 4. Iron gate valves.
 - 5. Bronze globe valves.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
- B. NSF Compliance: NSF 61 for valve materials for potable-water service.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
 - 2. Handwheel: For valves other than quarter-turn types.
 - 3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller.
- E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Solder Joint: With sockets according to ASME B16.18.
3. Threaded: With threads according to ASME B1.20.1.

2.2 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. Crane Co.; Crane Valve Group; Crane Valves.
 - d. Hammond Valve.
 - e. Lance Valves; a division of Advanced Thermal Systems, Inc.
 - f. Legend Valve.
 - g. Milwaukee Valve Company.
 - h. NIBCO INC.
 - i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE or TFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 200 CWP, Iron, Single-Flange Butterfly Valves with EPDM Seat and Aluminum-Bronze Disc:

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

- a. ABZ Valve and Controls; a division of ABZ Manufacturing, Inc.
- b. Conbraco Industries, Inc.; Apollo Valves.
- c. Cooper Cameron Valves; a division of Cooper Cameron Corporation.
- d. Crane Co.; Crane Valve Group; Jenkins Valves.
- e. Crane Co.; Crane Valve Group; Stockham Division.
- f. DeZurik Water Controls.
- g. Flo Fab Inc.
- h. Hammond Valve.
- i. Kitz Corporation.
- j. Legend Valve.
- k. Milwaukee Valve Company.
- l. NIBCO INC.
- m. Norriseal; a Dover Corporation company.
- n. Red-White Valve Corporation.
- o. Spence Strainers International; a division of CIRCOR International, Inc.
- p. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

- a. Standard: MSS SP-67, Type I.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
- e. Seat: EPDM.
- f. Stem: One- or two-piece stainless steel.
- g. Disc: Aluminum bronze.

2.4 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Division.
 - e. Hammond Valve.
 - f. Kitz Corporation.
 - g. Milwaukee Valve Company.
 - h. NIBCO INC.
 - i. Powell Valves.
 - j. Red-White Valve Corporation.
 - k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:

- a. Standard: MSS SP-80, Type 3.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: Bronze.

2.5 IRON GATE VALVES

A. Class 125, OS&Y, Iron Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.
 - d. Flo Fab Inc.
 - e. Hammond Valve.
 - f. Kitz Corporation.
 - g. Legend Valve.
 - h. Milwaukee Valve Company.
 - i. NIBCO INC.
 - j. Powell Valves.
 - k. Red-White Valve Corporation.
 - l. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

2.6 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Nonmetallic Disc:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. NIBCO INC.
 - d. Red-White Valve Corporation.

2. Description:

- a. Standard: MSS SP-80, Type 2.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
- d. Ends: Threaded or solder joint.
- e. Stem: Bronze.
- f. Disc: PTFE or TFE.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze.

PART 3 - EXECUTION

3.1 VALVE INSTALLATION

- A. Install valves with unions or flanges at every piece of equipment arranged to isolate individual piece of equipment and allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

3.2 VALVE MAP

- A. Provide a minimum 8-1/2x11 laminated floor plan of the building indicating the locations of all water shut off valves.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly, or gate valves.
 - 2. Throttling Service: Globe valves.
 - 3. Pump-Discharge Check Valves:

- a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze .
 - b. NPS 2-1/2 (DN 65) and Larger for Domestic Water: Iron swing check valves with lever and weight or with spring.
 - c. NPS 2-1/2 (DN 65) and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
 4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
 5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 2. Bronze Angle Valves: Class 125, bronze disc.
 3. Ball Valves: Two piece, full port, bronze with bronze trim.
 4. Bronze Swing Check Valves: Class 125, metallic disc.
 5. Bronze Gate Valves: Class 125, NRS.
 6. Bronze Globe Valves: Class 125, nonmetallic disc.
- B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Bronze Valves:: May be provided with threaded ends instead of flanged ends.
 2. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.
 1. Bronze Swing Check Valves: Class 125, metallic disc.
 2. Iron Gate Valves: Class 125, OS&Y.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Thermal-hanger shield inserts.
 - 4. Fastener systems.
 - 5. Pipe positioning systems.
 - 6. Equipment supports.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated.
 - 1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.

4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper- or epoxy-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.
 - c. Flex-Strut Inc.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut Corporation; Tyco International, Ltd.
 - g. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.

- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.6 PIPE STANDS

- A. Refer to details on the plans for specific products.
- B. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- C. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- D. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

2.7 PIPE POSITIONING SYSTEMS

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

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.

- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See other sections of the specifications for curbs.
- G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.

- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Saddles exposed to view shall have a paint grip surface.
 - b. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.

- b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
- 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use copper- or epoxy-plated pipe hangers and copper attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Saddles and shields exposed to view shall have a paint grip surface.

2. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 3. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 4. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Ceiling equipment markers
 - 5. Valve tags

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Aluminum, 0.032-inch (0.8-mm)] or anodized aluminum, 0.032-inch (0.8-mm) 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 (64 by 19 mm).
 - 3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 - 4. Fasteners: Stainless-steel rivets or self-tapping screws.
 - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) 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 (71 deg C).

5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 6. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Red.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Indicate pressure of any medium pressure piping; 2-PSI, 5-PSI, etc.

2.4 VALVE TAGS

- A. Brass: 1-1/2" diameter, 19 gauge thick, with 3/16" top hole for fastener, natural brass finish.
- B. Lettering: Stamped or Engraved letters; 1/4" lettering for system type, 1/2" text for valve number.
 - 1. Label valves per system type as follows:
 - a. DOMCW = Domestic cold water
 - b. DOMHW = Domestic hot water
 - c. DOMHWR = Domestic hot water recirculation
 - d. CHW = Chilled water
 - e. HW = Heating hot water
 - f. COND = Condenser water
- C. Beaded Chains: No. 6 brass, 114 mm (4-1/2") long, with locking link.
- D. Chart: Laminated, typewritten letter size list in anodized aluminum frame.

2.5 CEILING MARKERS:

- A. Provide markers on ceiling grids to indicate the locations of all valves.
- B. The marker shall be a paper dot, self-adhesive, 3/4 inch diameter, RED in color.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

- A. Locate pipe labels where piping is exposed in unfinished spaces 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. Label pipes in each and every room.
 - 2. Label pipes on the bottom and side of the pipe at intervals listed below.
 - 3. Near each valve and control device.
 - 4. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 5. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 6. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 7. Near major equipment items and other points of origination and termination.
 - 8. Spaced at maximum intervals of 10 feet along each run. Reduce intervals to 5 feet (7.6 m) in areas of congested piping and equipment.
- B. Pipe Label Color Schedule:
 - 1. Compressed-Air Piping:
 - a. Background Color: Blue.
 - b. Letter Color: White.
 - 2. Natural Gas & Propane Piping:
 - a. Background Color: Yellow.
 - b. Letter Color: Black
 - c. Indicate pressure of any indoor or roof mounted medium pressure piping; 2-PSI, 5-PSI, etc. including gas piping run on roof. Apply weatherproof label to roof mounted piping after piping has been painted.

3. Hot, Hot Water Recirculation, and Cold Domestic Water Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.
4. Storm Drain, Overflow Drain, and Sanitary Waste & Vent Piping:
 - a. Background Color: Green
 - b. Letter Color: White

3.4 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

3.5 VALVES AND EQUIPMENT ABOVE CEILING:

- A. Provide ceiling markers on the ceiling grid nearest the lay-in ceiling tile that should be removed for access to valves and equipment above the ceiling.

3.6 VALVE MAP

- A. Provide a minimum 8-1/2x11 laminated floor plan of the building indicating the locations of all water shut off valves.

END OF SECTION 220553

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SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Roof drains and rainwater leaders.
 - 5. Supplies and drains for handicap-accessible lavatories and sinks.
 - 6. Condensate drains

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing 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.
- B. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

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. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
- F. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000-Degree Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 - 2. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Noncombustible Plenum Insulation
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Unifrax I LLC, Niagara Falls, NY – FyreWrap 0.5 Plenum Insulation
 - 2. Materials

- a. Nominal 0.50" thick foil encapsulated blanket material at 8 PCF to provide noncombustible rating.
- b. An inorganic, non-asbestos, bio-soluble blanket material
- c. Blanket insulation must maintain a 2012 deg. F operating temperature.

2.2 INSULATING CEMENTS

A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

B. Flexible Elastomeric: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA, Inc.; Aeroseal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. 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."

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

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
2. 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).

3. 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."
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. 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."
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. 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."

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
 2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Solids Content: 60 percent by volume and 66 percent by weight.
 5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
4. Color: White or gray.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants 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. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: White.
 - 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.10 SECUREMENTS

- A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wing seal or closed seal.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. C & F Wire.

2.11 PROTECTIVE SHIELDING GUARDS

- A. Protective Shielding Pipe Covers:
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Engineered Brass Company.
 - b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
 - c. McGuire Manufacturing.
 - d. Plumberex.
 - e. Truebro; a brand of IPS Corporation.
 - f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
 2. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
- B. Protective Shielding Piping Enclosures:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Truebro; a brand of IPS Corporation.
 - b. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 - 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 for firestopping and fire-resistive joint sealers in other sections of the specifications.
- F. Insulation Installation at Floor Penetrations:
 - 1. Pipe: Install insulation continuously through floor penetrations.
 - 2. Seal penetrations through fire-rated assemblies. for firestopping and fire-resistive joint sealers in other sections of the specifications

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate 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 thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
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 (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as 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.

3.6 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE 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 (150 mm) o.c.
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.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), 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.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 FINISHES

- A. Exposed 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 selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. Inspect pipe, fittings, strainers, and valves, randomly selected by Engineer, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations

of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.10 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. All Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 1/2 inch thick.
- B. Domestic Hot Water:
 - 1. NPS 1-1/4 (DN 32) and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 1 inch (25 mm) thick.
 - 2. NPS 1-1/2 (DN 40) and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 1-1/2 inches (38 mm) thick.
- C. Domestic Recirculated Hot Water:
 - 1. All Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 1 inch (25 mm)
- D. Stormwater, Overflow, Roof Drain and Overflow Drain Bodies (only insulate the first 10 feet of overflow drains from the drain body):
 - 1. All Pipe Sizes: Insulation shall be one of the following:

- a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 1/2 inch thick.
 - 1) Insulate only the first 10 feet of overflow piping from drain body.
 - E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. Insulate with “Truebro LAV Guard 2” or equal product.
 - F. Condensate Drains:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 1/2 inch thick.
 - G. Sanitary Waste Piping Where Heat Tracing Is Installed:
 - 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric, or Mineral-Fiber, Preformed Pipe Insulation: 2 inches thick.
- 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. Piping, Concealed:
 - 1. Mineral-Fiber, Preformed Pipe Insulation: Kraft paper jacket
 - C. All Piping, Exposed, 10'-0" above finished floor and lower:
 - 1. PVC: 30 mils (0.8 mm) thick.

END OF SECTION 220719

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Copper tube and fittings.
 - 2. Piping joining materials.
 - 3. Transition fittings.
 - 4. Dielectric fittings.

1.3 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.
- B. Coordination Drawings: The contractor shall submit 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. Pipe installation (sanitary, water, storm, gas, etc.), indicating coordination with general construction, building components including structure, HVAC equipment and ductwork, sprinkler piping, electrical panels, service and conduits, cable trays, and other building services. Indicate proposed changes to pipe layout.
 - 2. Suspended ceiling components.
 - 3. Size and location of access to concealed valves and equipment.
 - 4. Penetrations of smoke barriers and fire-rated construction.
- C. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.4 INFORMATIONAL SUBMITTALS

- A. System purging and disinfecting activities report.
- B. Field quality-control reports.

1.5 FIELD CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than 4 days in advance of proposed interruption of water service.
 - 2. Do not interrupt water service without Construction Manager's and Owner's written permission.

1.6 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for potable domestic water piping and components.
- C. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by the same manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.7 REFERENCES

- A. ASTM International (ASTM):
 - 1. ASTM D 2765 - Test Methods for Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics.
 - 2. ASTM D 6394 - Specification for Sulfone Plastics (SP).
 - 3. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
 - 4. ASTM E 119 - Standard Test Methods for Fire Tests of Building Construction and Materials.
 - 5. ASTM E 814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- B. Potable-water piping and components shall comply with NSF 14 and NSF 61 Annex G. Plastic piping components shall be marked with "NSF-pw."
- C. Comply with NSF 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) water tube, annealed temper.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- F. Copper Unions:
 - 1. MSS SP-123.
 - 2. Cast-copper-alloy, hexagonal-stock body.
 - 3. Ball-and-socket, metal-to-metal seating surfaces.
 - 4. Solder-joint or threaded ends.
- G. Copper Press-Connect Fittings:
- H. Press fitting: copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of ASME B16.51 and IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have Smart Connect® technology. In ProPress ½" to 4" dimensions, Smart Connect technology allows identification of an unpressed fitting during pressure testing. The function of this feature is to provide the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials:
 - 1. AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
 - 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys.
- D. Flux: ASTM B 813, water flushable.
- E. Brazing Filler Metals: AWS A5.8M/A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- F. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

D. Plastic-to-Metal Transition Fittings:

1. Description:
 - a. CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions.
 - b. One end with threaded brass insert and one solvent-cement-socket or threaded end.

E. Plastic-to-Metal Transition Unions:

1. Description:
 - a. CPVC four-part union.
 - b. Brass or stainless-steel threaded end.
 - c. Solvent-cement-joint or threaded plastic end.
 - d. Rubber O-ring.
 - e. Union nut.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Standard: ASSE 1079.
2. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Standard: ASSE 1079.
2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Nonconducting materials for field assembly of companion flanges.
2. Pressure Rating: 150 psig (1035 kPa).
3. Gasket: Neoprene or phenolic.
4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Standard: IAPMO PS 66.
2. Electroplated steel nipple complying with ASTM F 1545.
3. Pressure Rating and Temperature: 300 psig (2070 kPa) at 225 deg F (107 deg C).
4. End Connections: Male threaded or grooved.
5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 312000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install underground copper tube and ductile-iron pipe in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
- E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each domestic water-service entrance. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."
- F. Install shutoff valve immediately upstream of each dielectric fitting.
- G. Install valves to isolate at a minimum each wing of a building, each room, each mechanical room, each piece of equipment and elsewhere as shown on the plans.

- H. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."
- I. Install domestic water piping level with 0.25 percent slope downward toward drain.
- J. Rough-in domestic water piping for water-meter installation according to utility company's requirements.
- K. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- L. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- M. 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.
- N. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- O. Install piping to permit valve servicing.
- P. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- Q. Install piping free of sags and bends.
- R. Install fittings for changes in direction and branch connections.
- S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- T. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."
- U. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."
- V. Install thermometers on outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Braze Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. Pressure-Sealed Joints for Copper Tubing: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.
- G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
- H. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. Fittings for NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
 - 2. Fittings for NPS 2 (DN 50) and Larger: Sleeve-type coupling.
- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 (DN 50) and Smaller: Plastic-to-metal transition fittings or unions.

3.5 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric couplings.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flange kits.
- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - 4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
 - 5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
 - 6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
 - 7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.
- F. Install supports for vertical copper tubing every 10 feet (3 m).

- G. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
 - 1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
 - 2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - 3. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 - 4. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Label pressure piping with system operating pressure.

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.

- 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
2. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
 - c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.10 ADJUSTING

- A. Perform the following adjustments before operation:
 1. Close drain valves, hydrants, and hose bibbs.
 2. Open shutoff valves to fully open position.
 3. Open throttling valves to proper setting.
 4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
 5. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.

8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

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

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

3.12 PIPING SCHEDULE

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

- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Under-building-slab, domestic water, building-service piping, NPS 3 (DN 80) and smaller, shall be one of the following:
 - 1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A); wrought-copper, solder-joint fittings; and brazed joints.
 - 2. Underground insulated piping: See section 221117 Pre-Insulated Domestic Water Piping.
- D. Under-building-slab, domestic water, building-service piping, NPS 4 and larger, shall be one of the following:
 - 1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A; wrought-copper, solder-joint fittings; and brazed joints.
- E. Under-building-slab, domestic water piping, NPS 2 and smaller shall be the following:
 - 1. Copper tube, ASTM B88, Type L (ASTM B88M, Type B); wrought-copper, solder-joint fittings; and brazed or copper pressure-seal-joint fittings; and pressure-sealed joints.
- F. Aboveground domestic water piping,
 - 1. NPS 2 (DN 50) and smaller, shall be one of the following:
 - a. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B cast- or wrought-copper, solder-joint fittings; and soldered joints.
 - b. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B copper press-connect fittings; and press-connect joints.
- G. Aboveground domestic water piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100, shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B cast- or wrought copper, solder-joint fittings; and soldered joints.
 - 2. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B copper press-connect fittings; and press-connect joints.
- H. Aboveground domestic water piping, NPS 5 to NPS 8 (DN 125 to DN 200, shall be one of the following:
 - 1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B cast- or wrought-copper, solder-joint fittings; and brazed joints.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

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 domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Strainers.
6. Outlet boxes.
7. Hose bibbs.
8. Wall hydrants.
9. Drain valves.
10. Water hammer arresters.
11. Air vents.
12. Trap-seal primer valves.
13. Trap-seal protection devices.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 and NSF 14. Mark "NSF-pw" on plastic piping components, shall be certified to the low lead requirements of NSF-372.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig (860 kPa) unless otherwise indicated.

2.3 VACUUM BREAKERS

A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Cash Acme.
 - c. Conbraco Industries, Inc.
 - d. FEBCO; SPX Valves & Controls.
 - e. Rain Bird Corporation.
 - f. Toro Company (The); Irrigation Div.
 - g. Watts Industries, Inc.; Water Products Div.
 - h. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1001.
3. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Rough bronze.

B. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Arrowhead Brass Products, Inc.
 - b. Cash Acme.
 - c. Conbraco Industries, Inc.
 - d. Legend Valve.
 - e. MIFAB, Inc.
 - f. Prier Products, Inc.
 - g. Watts Industries, Inc.; Water Products Div.
 - h. Woodford Manufacturing Company.
 - i. Zurn Plumbing Products Group; Light Commercial Operation.
 - j. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Rough bronze.

C. Pressure Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.

- c. FEBCO; SPX Valves & Controls.
 - d. Flomatic Corporation.
 - e. Toro Company (The); Irrigation Div.
 - f. Watts Industries, Inc.; Water Products Div.
 - g. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1020.
 3. Operation: Continuous-pressure applications.
 4. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.
 5. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Standard: ASSE 1013.
2. Operation: Continuous-pressure applications.
3. Pressure Loss: 14 psig maximum, through middle third of flow range.
4. Body: Bronze for NPS 2 (DN 50) and smaller; [cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

B. Double-Check, Backflow-Prevention Assemblies:

1. Standard: ASSE 1015.
2. Operation: Continuous-pressure applications unless otherwise indicated.
3. Pressure Loss: 7 psig maximum, through middle third of flow range.
4. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
5. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
6. Configuration: Designed for horizontal, straight-through flow.
7. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.

C. Beverage-Dispensing-Equipment Backflow Preventers:

1. Standard: ASSE 1022.
2. Operation: Continuous-pressure applications.
3. Size: NPS 1/4 or NPS 3/8 (DN 8 or DN 10).
4. Body: Stainless steel.
5. End Connections: Threaded.

2.5 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Standard: ASSE 1003.
2. Pressure Rating: Initial working pressure of 150 psig (1035 kPa).
3. Size: Line size of incoming water service.
4. Design Inlet Pressure: (confirm pressure at the subject project site).
5. Design Outlet Pressure Setting: 75 psig.
6. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
7. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

2.6 BALANCING VALVES

A. Pressure Independent Flow Limiting Valve

1. Valve body shall be constructed out of DZR brass and rated for 400 PSIG working pressure.
2. Valve shall include an integrated chrome plated brass ball valve.
3. Valve body shall include two pressure\temperature ports.
4. Valve shall utilize a removable differential pressure regulating cartridge.
5. Removable differential pressure cartridge shall utilize a removable orifice plate to set the maximum flow through the valve.
6. Removable orifice plate shall be designed to maintain its size and shape while system is in operation. Additionally, the Cv through the orifice plate shall not change while the system is in operation.
7. Removable differential pressure cartridge shall feature a rolling EPDM rubber diaphragm to eliminate metal-on-metal contact and leak paths.
8. Valve body shall have the ability to accommodate a union ended tailpiece with SWTF, male NPT thread, female NPT thread connections and a union nut that can secure the tailpiece to the body of the valve to create a water-tight seal
9. Valve shall have maximum differential pressure limit of 60 psid.
10. Valve temperature range shall be from -4°F (-20°C) to 250°F (121°C).
11. Accessories:
 - a. Extended Pressure/Temperature Ports
 - b. Extended Handle

B. Automatic Flow Controller For Drinking Water Applications

1. Victaulic "ICSS" SERIES 76X 1/2 and 3/4" [15 and 20mm]
 - a. Designed specifically for use in drinking water applications, NSF/ANSI 61-G rated for commercial hot water service (temperature rated to 180F), and certified by the NSF with all wetted parts stainless steel; lead-free construction in compliance with ANS/NSF-372; Series 300 stainless steel body, nickel plated brass union nut, and tamper-resistant flow cartridge 300 series stainless steel. Valve shall be suitable for maximum flow of 12 gallons per minute, and flow rate pre-set accuracy variation of +/-5% over 95% of the control range. Valves shall have a full body rating of 400 psi, but is suitable for working pressures with differential control ranges of 2 - 32 psi or 5 - 60 psi differential. All wetted parts shall comply with NSF/ANSI Standard 372 for minimal lead content. Compact in-line design for tight installations.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig (860 kPa) minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 (DN 50) and Smaller: 0.020 inch.
 - b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.045 inch.
 - c. Strainers NPS 5 (DN 125) and Larger: 0.125 inch.
6. Drain: Pipe plug.

2.8 OUTLET BOXES

A. Clothes Washer Outlet Boxes: See Plumbing Fixture Schedule on plans.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company.
 - b. Guy Gray Manufacturing Co., Inc.
 - c. IPS Corporation.
 - d. LSP Products Group, Inc.
 - e. Symmons Industries, Inc.
 - f. Watts Industries, Inc.; Water Products Div.

- g. Whitehall Manufacturing; a div. of Acorn Engineering Company.
- h. Zurn Plumbing Products Group; Light Commercial Operation.

- 2. Mounting: Recessed.

2.9 HOSE BIBBS

- A. Hose Bibbs: See Plumbing Fixture Schedule on plans

- 1. Standard: ASME A112.18.1 for sediment faucets.
- 2. Body Material: Bronze.
- 3. Seat: Bronze, replaceable.

2.10 WALL HYDRANTS

- A. Nonfreeze Wall Hydrants: See Plumbing Fixture Schedule on plans

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Prier Products, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Woodford Manufacturing Company.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.

2.11 WATER HAMMER ARRESTERS

- A. Water Hammer Arresters:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. PPP Inc.
 - e. Sioux Chief Manufacturing Company, Inc.
 - f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - g. Tyler Pipe; Wade Div.
 - h. Watts Drainage Products Inc.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.

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

2.12 AIR VENTS

A. Bolted-Construction Automatic Air Vents :

1. Body: Bronze.
2. Pressure Rating: 125-psig (860-kPa) minimum pressure rating at 140 deg F (60 deg C).
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 1/2 (DN 15) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents :

1. Body: Stainless steel.
2. Pressure Rating: 150-psig (1035-kPa) minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 (DN 10) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.13 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves :

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. MIFAB, Inc.
 - b. PPP Inc.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Watts Industries, Inc.; Water Products Div.
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig (860 kPa) minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.14 TRAP SEAL PROTECTION DEVICES

A. Barrier Type Trap Seal Protection Devices :

1. Basis-of-Design Product: Subject to acceptance by the local jurisdiction, provide SureSeal Manufacturing; Inline Floor Drain Trap Sealer, or a comparable product with IAPMO approval from another manufacturer.
2. Standard: ASSE 1072-2007.
3. Body: ASB Plastic
4. Diaphragm & Sealing Gasket: Neoprene Rubber
5. Size: 2 inch (50 mm), 3 inch (75 mm), 3-1/2 inch (89 mm), or 4 inch (100 mm).
6. Gravity Drain Outlet Connection: Compression fit sealing gasket 80 durometer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Section 220500 "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
1. Locate backflow preventers in same room as connected equipment or system. Install at floor level or as shown on the plans.
 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to outdoors. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
 3. Do not install bypass piping around backflow preventers.
- C. Install balancing valves at the end of each hot water recirculation line and other locations as required to balance the recirculation system flow.
1. Install balancing valves in locations where they can easily be adjusted.
- D. Install water pressure-reducing valves where the incoming pressure is greater than 80 psi.
- E. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve.
- F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

- a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
 - b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
 - c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
5. Install trap-seal protection devices in all floor drains during trim out stage of project.
- G. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs.
- H. Install nonfreeze, nondraining-type post hydrants set in concrete or pavement.
- I. Install water hammer arresters in water piping according to PDI-WH 201.
- J. Install air chambers at each plumbing fixture supply line.
- K. Install supply-type, trap-seal primer valves or Barrier Type Trap Seal Protection Devices on all traps subject to evaporation (floor drains, floor sinks, etc.). Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding."
- C. Connect wiring according to Division 26 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, double-check, backflow-prevention assembly and double-check, detector-assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Set field-adjustable pressure set points of water pressure-reducing valves.
- B. Set field-adjustable flow set points of balancing valves.
- C. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221119

SECTION 221123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. In-line, wet rotor circulators.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 IN-LINE, WET ROTOR CIRCULATORS

- A. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
1. Armstrong Pumps Inc.
 2. Bell & Gossett Domestic Pump; ITT Corporation.
 3. Grundfos Pumps Corp.
 4. TACO Incorporated.
 5. Wilo
- B. Pump Construction:
1. Pump Body: Lead free bronze
 2. Impeller: Noryl
 3. Shaft: Ceramic
 4. Bearings: Double-Sintered Carbon
- C. Capacities and Characteristics: As indicated on the plans.

2.2 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors appropriate for the proposed service.
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.3 CONTROLS

- A. Thermostats: Electric; adjustable for control of hot-water circulation pump.
1. Type: Water-immersion temperature sensor, for installation in piping.
 2. Range: 65 to 200 deg F (18 to 93 deg C).
 3. Operation of Pump: On or off.
 4. Transformer: Provide if required.
 5. Settings: Start pump at 110 deg F and stop pump at 120 deg F.
- B. Timers: Electric, for control of hot-water circulation pump.
1. Type: Programmable, seven-day clock with manual override on-off switch.
 2. Operation of Pump: On or off.
 3. Transformer: Provide if required.
 4. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install pumps with shaft horizontal unless otherwise indicated.
- C. Install continuous-thread hanger rods of size required to support pump weight (if weight is such that support by connecting piping is not adequate). Support per manufacturer's instructions.
- D. Install thermostats in hot-water return piping.
- E. Install timers on wall adjacent to water heater.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
- D. Connect thermostats and timers to pumps that they control.

3.3 ADJUSTING

- A. Install balancing valves at the end of each hot water recirculation line and other locations as required to balance the recirculation system flow.
 - 1. Install balancing valves in locations where they can easily be adjusted.
- B. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- C. Adjust initial temperature set points.
- D. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 221123

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SECTION 221125 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.
 - 6. Painting of natural gas piping

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig (450 kPa) minimum unless otherwise indicated.
- B. Natural-Gas System Pressure within Buildings: 0.5 psig (3.45 kPa) or less.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of piping specialty, valve, or regulator. Submittals not required on pipe or tubing.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control and test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 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 shall be qualified, licensed within the jurisdiction, and familiar with the installation of cold press mechanical joint systems.
- E. MegaPressG press fittings shall be installed using the proper tool, actuator, jaws and rings as instructed by the press fitting manufacturer.
- F. The installation of black steel pipe in natural gas systems shall conform to the requirements of the ICC International Mechanical Code or the IAPMO Uniform Plumbing Code or National Fuel Gas Code.
- G. Compliance to ASME B31.9 for building services piping valves.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Mechanical joint fittings: Cold Press Mechanical Joint Fitting shall conform to material requirements of ASTM A420 or ASME B16.3 and performance criteria ANSI/CSA LC4. Sealing elements for press fittings shall be HNBR. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect™) feature design (leakage path). MegaPress fittings with the Smart Connect Feature assure leakage of liquids and/or gases from inside the system past the sealing element of an un-pressed connection. The function of this feature is to provide the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation. Piping and fittings shall comply with CSA LC-4 and the latest edition of NFPA-54. Fittings shall comply to the requirements of ASTM F3226.
 - 4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.

- a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. OmegaFlex, Inc.
 - b. Parker Hannifin Corporation; Parflex Division.
 - c. Titeflex.
 - d. Tru-Flex Metal Hose Corp.
 2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
 3. Coating: PE with flame retardant.
 - a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 25 or less.
 - 2) Smoke-Developed Index: 50 or less.
 4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
 5. Striker Plates: Steel, designed to protect tubing from penetrations.
 6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
 7. Operating-Pressure Rating: 5 psig (34.5 kPa).
- C. PE Pipe: ASTM D 2513, SDR 11.
1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
 2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 3. Anodeless Service-Line Risers: Factory fabricated and leak tested.
 - a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
 - b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
 - c. Aboveground Portion: PE transition fitting.
 - d. Outlet shall be threaded or suitable for welded connection.
 - e. Tracer wire connection.
 - f. Ultraviolet shield.
 - g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

4. Transition Service-Line Risers: Factory fabricated and leak tested.
 - a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
 - b. Outlet shall be threaded or suitable for welded connection.
 - c. Bridging sleeve over mechanical coupling.
 - d. Factory-connected anode.
 - e. Tracer wire connection.
 - f. Ultraviolet shield.
 - g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig (3.45 kPa).
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches (1830 mm.)

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. 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 (DN 50) and smaller.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (862 kPa).

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F (540 deg C) complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 (DN 50) and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig (862 kPa).
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 - 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch (25 mm) and smaller.
 - 6. Service Mark: Valves 1-1/4 inches (32 mm) to NPS 2 (DN 50) shall have initials "WOG" permanently marked on valve body.
- C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated bronze.
 - 4. Stem: Bronze; blowout proof.
 - 5. Seats: Reinforced TFE; blowout proof.
 - 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 - 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 8. CWP Rating: 600 psig (4140 kPa).
 - 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated brass.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Separate packnut with adjustable-stem packing threaded ends.
7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig (4140 kPa).
9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lee Brass Company.
 - b. McDonald, A. Y. Mfg. Co.
2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig (862 kPa).
7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

F. PE Ball Valves: Comply with ASME B16.40.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kerotest Manufacturing Corp.
 - b. Lyall, R. W. & Company, Inc.
 - c. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: PE.
3. Ball: PE.
4. Stem: Acetal.
5. Seats and Seals: Nitrile.
6. Ends: Plain or fusible to match piping.
7. CWP Rating: 80 psig (552 kPa)
8. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C)].
9. Operator: Nut or flat head for key operation.
10. Include plastic valve extension.
11. Include tamperproof locking feature for valves where indicated on Drawings.

G. Valve Boxes:

1. Cast-iron, two-section box.
2. Top section with cover with "GAS" lettering.
3. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
4. Adjustable cast-iron extensions of length required for depth of bury.
5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.5 MOTORIZED GAS VALVES

A. Electrically Operated Valves: Comply with UL 429.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ASCO Power Technologies, LP; Division of Emerson.
 - b. Dungs, Karl, Inc.
 - c. Eclipse Combustion, Inc.
 - d. Goyen Valve Corp.; Tyco Environmental Systems.
 - e. Magnatrol Valve Corporation.
 - f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
 - g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Visual position indicator.

2.6 PRESSURE REGULATORS

A. General Requirements:

1. All regulators shall be suitable for the service and location where they are to be installed (indoors, outdoors, etc.)
2. Single stage and suitable for natural gas.
3. Steel jacket and corrosion-resistant components.
4. Elevation compensator.
5. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Eclipse Combustion, Inc.
 - d. Fisher Control Valves and Regulators; Division of Emerson Process Management.
 - e. Invensys.
 - f. Maxitrol Company.
 - g. Richards Industries; Jordan Valve Div.
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig (13.8 kPa).

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig (13.8 kPa)

2.7 DIELECTRIC UNIONS

A. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Jomar International Ltd.
 - e. Matco-Norca, Inc.
 - f. McDonald, A. Y. Mfg. Co.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - h. Wilkins; a Zurn company.
2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.8 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

PART 3 - EXECUTION

3.1 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

- B. Install underground, natural-gas piping buried at least 36 inches (900 mm) below finished grade.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- E. Install fittings for changes in direction and branch connections.
- F. Install pressure gage downstream from each service regulator.

3.2 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches (75 mm) long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches (38 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - 3. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 - 4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 5. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment.

- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install pressure gage downstream from each line regulator.
- W. Install sleeves for piping penetrations of walls, ceilings, and floors.
- X. Install sleeve seals for piping penetrations of concrete walls and slabs.
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 PAINTING

- A. Comply with requirements in other sections of the specifications for painting interior and exterior natural-gas piping.
- B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel (flat).
 - d. Color: To match adjacent surfaces. Piping run on roof surface to be painted yellow.
- C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior latex matching topcoat.
 - c. Topcoat: Interior latex (flat).
 - d. Color: Exposed in normally occupied space color to match adjacent surfaces. Piping run exposed in back of house not normally occupied spaces (mechanical rooms) color to be yellow.
 - 2. Alkyd System: MPI INT 5.1E.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior alkyd matching topcoat.
 - c. Topcoat: Interior alkyd (flat).

- d. Color: Exposed in normally occupied space color to match adjacent surfaces. Piping run exposed in back of house not normally occupied spaces (mechanical rooms) color to be yellow.

- D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.4 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing or copper connector.
- B. Install underground valves with valve boxes.
- C. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- D. Install earthquake valves aboveground outside buildings according to listing.
- E. Install anode for metallic valves in underground PE piping.

3.5 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in other sections of these specifications.
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
 2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
- C. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
 1. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
 2. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
 3. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).

3.7 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1800 mm) of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.8 LABELING AND IDENTIFYING

- A. Comply with requirements in other sections of these specifications.

- B. Install detectable warning tape directly above gas piping, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.
- C. Label each system pressure class for identification (high pressure, medium pressure, low pressure)

3.9 FIELD QUALITY CONTROL

- A. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.
- B. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.10 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be one of the following:
 - 1. PE pipe and fittings joined by heat fusion; service-line risers with tracer wire terminated in an accessible location.
 - 2. Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
 - 3. Annealed-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
- B. Aboveground natural-gas piping NPS 3 and smaller shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
 - 3. Steel pipe with press-connect fittings and press-connect joints.
- C. Aboveground natural-gas piping larger than NPS 3 shall be:
 - 1. Steel pipe with wrought-steel fittings and welded joints.
- D. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.11 INDOOR PIPING SCHEDULE

- A. Aboveground, concealed, branch piping (to fixtures and equipment) 0.5 psig (3.45 kPa) or less, NPS 2 and smaller shall be one of the following:
 - 1. Where approved by the jurisdiction having authority, corrugated stainless-steel tubing (CCST) with mechanical fittings having socket or threaded ends to match adjacent piping.

- a. Corrugated stainless steel tubing gas piping systems shall be bonded to the electrical service grounding electrode system. The bonding jumper shall connect to a metallic pipe or fitting between the point of delivery and the first downstream CSST fitting. The bonding jumper shall be not smaller than 6 AWG copper wire or equivalent. Gas piping systems that contain one or more segments of CSST shall be bonded in accordance with the above. It shall be the responsibility of the contractor providing and installing CSST to provide and install the required bonding jumpers.
2. Steel pipe with malleable-iron fittings and threaded joints.
3. Steel pipe with mechanical joint fittings.
- B. Aboveground, exposed, branch piping (to fixtures and equipment) 0.5 psig (3.45 kPa) or less, NPS 3 and smaller shall be one of the following:
 1. Steel pipe with malleable-iron fittings and threaded joints.
 2. Steel pipe with press-connect fittings and press-connect joints
- C. Aboveground, distribution piping 0.5 psig (3.45 kPa) or less, NPS 3 and smaller shall be one of the following:
 1. Steel pipe with malleable-iron fittings and threaded joints.
 2. Steel pipe with wrought-steel fittings and welded joints.
 3. Steel pipe with press-connect fittings and press-connect joints (NPS 4 and smaller).
- D. Aboveground, distribution piping 0.5 psig (3.45 kPa) or less, larger than NPS 3 shall be:
 1. Steel pipe with wrought-steel fittings and welded joints.
- E. Aboveground, distribution piping above 0.5 psig (3.45 kPa) shall be:
 1. Steel pipe with wrought-steel fittings and welded joints.
- F. Underground, below building slab, piping shall be:
 1. Corrugated stainless-steel tubing (CCST) with mechanical fittings having socket or threaded ends to match adjacent piping installed in containment conduit as described in 3.11, H.
- G. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- H. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.12 UNDERGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
- B. Underground: PE or Bronze plug valves.

3.13 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be the following:
 - 1. One-piece, bronze ball valve with bronze trim.
- B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
- D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- E. Valves in branch piping for single appliance shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.

END OF SECTION 221123

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SECTION 221313 - SANITARY SEWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes gravity-flow, sanitary sewerage outside the building, with the following components:
 - 1. Piping.
 - 2. Cleanouts.
 - 3. Precast concrete manholes.
- B. Related Sections include the following:
 - 1. Section 312000 "Earth Moving" for excavation, trenching and backfilling requirements.

1.3 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Product Data: For each type of product
- B. Shop Drawings: For the following:
 - 1. Manholes: Include plans, elevations, sections, details, and frames and covers.
- C. Field quality-control test reports.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic, pipe, and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.

- C. Handle manholes according to manufacturer's written rigging instructions.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Sewerage 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 The Metropolitan Community College no fewer than three days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without the Metropolitan Community College's written permission.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

- A. PVC Sewer Pipe and Fittings,
 - 1. NPS 15 and Smaller: ASTM D 3034, SDR 26, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.
 - 2. NPS 18 and Larger: ASTM F679, Wall Thickness T-1, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.2 CLEANOUTS

- A. PVC Cleanouts: PVC body with Brass threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.3 MANHOLES

- A. Standard Precast Concrete Manholes: ASTM C 478 precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 - 1. Diameter: 48 inches minimum, unless otherwise indicated.
 - 2. Manholes shall conform to the City of Lee's Summit, Missouri Standard Specification Section 3500 and standard drawing SAN-2.

2.4 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
 - 1. Cement: ASTM C 150, Type II.
 - 2. Fine Aggregate: ASTM C 33, sand.
 - 3. Coarse Aggregate: ASTM C 33, crushed gravel.

4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Division 31 Section: "Earth Moving".

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections, unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.
- F. Install gravity-flow, drainage piping according to the following:
 1. Install piping pitched down in direction of flow, at slope indicated.

2. Install piping below frost line.
 3. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
- G. Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, drainage piping according to the following:
1. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasket joints.

3.4 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Form continuous concrete channels and benches between inlets and outlet.
- D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops as indicated in other areas.
- E. Install manhole cover inserts in frame and immediately below cover.

3.5 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318/318R.

3.6 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use PVC pipe fittings in sewer pipes at branches for cleanouts and PVC pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
1. Use medium-duty, top-loading classification cleanouts in paved foot-traffic areas.
 2. Use heavy-duty, top-loading classification cleanouts in vehicle-traffic service areas.
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops to match surrounding grade.
- C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.7 CONNECTIONS

- A. Connect gravity-flow drainage piping to building's sanitary building drains.
- B. Make connections to existing piping and underground manholes.
 - 1. Make connections in accordance with Independence, Missouri standards.
 - 2. Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 CLOSING ABANDONED SANITARY SEWERAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Close open ends of piping with at least 8-inch-thick, concrete plugs. Fill pipe with flowable fill.
- B. Abandoned Manholes: Excavate around manhole as required and use either procedure below:
 - 1. Remove manhole and close open ends of remaining piping.
 - 2. Remove top of manhole or structure down to at least 36 inches below final grade. Fill to top with flyash, gravel, or compacted dirt. Fill to top with concrete.
- C. Backfill to grade according to Division 31 Section: "Earth Moving."

3.9 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate report for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
 - 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.

2. Test completed piping systems according to requirements of authorities having jurisdiction.
 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 4. Submit separate report for each test.
 5. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
 6. Manholes: Perform hydraulic test according to ASTM C 969.
- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.10 CLEANING

- A. Clean interior of piping of dirt and superfluous material.

END OF SECTION 221313

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sanitary waste and vent piping
 - 2. Condensate-drain piping
 - 3. Pipe, tube, and fittings.
 - 4. Specialty pipe fittings.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit 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. Pipe installation, indicating coordination with general construction, building components including structure, HVAC equipment and ductwork, sprinkler piping, electrical panels, service and conduits, cable trays, and other building services. Indicate proposed changes to pipe layout.
 - 2. Suspended ceiling components.
 - 3. Size and location of access to concealed valves and equipment.
 - 4. Penetrations of smoke barriers and fire-rated construction.
- B. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.4 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.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 - 1. Condensate-Drain Piping: 150 deg F (66 deg C).

2.2 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.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
- B. CISPI, Hubless-Piping Couplings:
 - 1. Shielded Couplings: Assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310 and ASTM C 1277, with stainless steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve & bear the NSF Trademark.

2.4 SANITARY WASTE & VENT PVC PIPE AND FITTINGS

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

2.5 CONDENSATE DRAIN 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.

2.6 COPPER TUBE AND FITTINGS

- A. Copper Type DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- C. Hard Copper Tube: ASTM B 88, Type L and Type M (ASTM B 88M, Type B and Type C), water tube, drawn temper.
- D. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
- E. Copper Pressure Fittings:
 1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
 2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.7 JOINING MATERIALS

- A. Solvent Cements for Joining Plastic Piping:
 1. CPVC Piping: ASTM F 493.
 - a. CPVC solvent cement shall have a VOC content of 490 g/L or less.
 - b. Adhesive primer shall have a VOC content of 550 g/L or less.
 - c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
 2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 - a. PVC solvent cement shall have a VOC content of 510 g/L or less.
 - b. Adhesive primer shall have a VOC content of 550 g/L or less.

- c. Solvent cement and adhesive primer shall comply with the testing and product requirements of the California Department of Public Health's (formerly, the California Health Services') "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

2.8 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. Shielded, Nonpressure Transition Couplings:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company; 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.

2.9 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A.Y. McDonald Mfg. Co.
 - b. Capitol Manufacturing Company.
 - c. Central Plastics Company.
 - d. Hart Industries International, Inc.
 - e. Jomar International Ltd.
 - f. Matco-Norca.
 - g. Watts Regulator Co.

- h. Victaulic Company Of America.
- i. Zurn Industries, LLC.

C. Dielectric Waterways

- 1. 1/2 inch (DN15) through 4 inch (DN100) sizes, IPS to copper-tubing size dielectric transition fitting. Fittings shall be a copper-silicon casting conforming to UNS C87850, and UL classified in accordance with ANSI / NSF-61 for potable water service. Fittings shall have threaded ends, grooved ends, or a combination.

PART 3 - EXECUTION

3.1 PLENUM PIPING

- A. With the approval of the local jurisdiction, plastic piping as specified may be used and where located in return air plenums shall be wrapped with noncombustible insulation listed for plenum installation with a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84.

3.2 EARTH MOVING

- A. Comply with requirements in other sections of these specifications for excavating, trenching, and backfilling.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.

- H. Make changes in direction for condensate drain, 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.
- I. 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.
- J. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- K. 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."
- L. Install aboveground PVC piping according to ASTM D 2665.
- M. Install underground PVC piping according to ASTM D 2321.
- N. 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. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
 - 2. Install cleanouts located not more than 100 feet apart, at changes in direction greater than 45 degrees and at the base of each waste or soil stack.
 - 3. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Section 221319 "Sanitary Waste Piping Specialties."
- O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors.
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs.

- R. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- S. Pipe indoor condensate drains to appropriate receptors as shown on the plans.
- T. Pipe outdoor condensate drains to nearest roof drain, downspout or other location as indicated on the plans. Do not spill on roof unless indicated on plans.

3.4 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

3.5 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. 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. 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.
- E. 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.
 - 4. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.6 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in OD's.
 - 2. In Drainage Piping: Shielded, nonpressure transition couplings.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install stainless-steel pipe hangers for horizontal piping in corrosive environments.
 - 3. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 4. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 - 5. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 6. Install individual, straight, horizontal piping runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 - 7. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 8. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Install hangers and supports for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 - 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 - 4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 - 5. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
- G. Install hangers and supports for ABS and PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1 and Smaller: Maximum span, 3 feet.
 - 2. NPS 1-1/4 and Larger: Maximum span, 4 feet.
- H. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).

- I. Install hangers and supports for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1-1/4 and Smaller: Maximum span, 6 feet; minimum rod size, 3/8 inch (10 mm).
 - 2. NPS 1-1/2 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch (10 mm).
- J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.8 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. Install horizontal backwater valves in pit with pit cover flush with floor.
 - 6. Comply with requirements for backwater valves, cleanouts, and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
 - 7. Equipment: Connect drainage piping as indicated. Provide shutoff valve if indicated and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) 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 NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.9 IDENTIFICATION

- A. Identify sanitary waste and vent piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.10 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 (30 kPa). 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 (250 Pa). 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.

3.11 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.

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

3.12 PIPING SCHEDULE

- A. Aboveground, soil and waste piping shall be one of the following:
 - 1. Hubless cast-iron soil pipe and fittings regular-duty shielded, stainless-steel couplings; and hubless-coupling joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints wrapped with noncombustible insulation listed for plenum installation.
- B. Underground, soil and waste piping shall be any of the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. Aboveground force mains shall be any of the following:
 - 1. Galvanized steel pipe, pressure fittings, and threaded joints.
 - 2. Type L copper, soldered joints.
- D. Above and below ground vent piping shall be any of the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints. Where installed in plenums, wrap with noncombustible insulation listed for plenum installation.
- E. Condensate-Drain Piping:
 - 1. Indoor Piping: Type M (Type C), drawn-temper copper tubing, wrought-copper fittings, and soldered joints or pressure seal joints.
 - 2. Outdoor Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

END OF SECTION 221316

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SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Cleanouts.
2. Floor drains.
3. Roof flashing assemblies.
4. Miscellaneous sanitary drainage piping specialties.
5. Flashing materials.
6. Storm shelter vent penetration protection

1.3 ACTION SUBMITTALS

- A. Product Data: Provide product data for storm shelter vent penetration protection.

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 CLEANOUTS

- A. Exposed Cast-Iron Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Tyler Pipe.
 - e. Wade

- f. Watts Drainage Products.
- g. Zurn Plumbing Products Group.
- 2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
- 3. Size: Same as connected drainage piping
- 4. Body Material: Hubless, cast-iron soil pipe test tee] as required to match connected piping.
- 5. Closure: Countersunk cast-iron plug.
- 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. Oatey.
 - c. Sioux Chief Manufacturing Company, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Wade
 - g. Watts Drainage Products Inc.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.36.2M for adjustable housing cleanout.
- 3. Size: Same as connected branch.
- 4. Type: Cast-iron soil pipe with cast-iron ferrule.
- 5. Body or Ferrule: Cast iron.
- 6. Outlet Connection: Threaded.
- 7. Closure: Brass plug with tapered threads.
- 8. Adjustable Housing Material: Cast iron with threads.
- 9. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
- 10. Frame and Cover Shape: Round.

C. Cast-Iron Wall Cleanouts:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Wade
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
- 2. Standard: ASME A112.36.2M. Include wall access.
- 3. Size: Same as connected drainage piping.

4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Commercial Enameling Co.
 - b. Josam Company; Josam Div.
 - c. MIFAB, Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Wade
 - g. Watts Drainage Products Inc.
 - h. Zurn Plumbing Products Group; Light Commercial Operation.
 - i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Pattern: Floor drain.
3. Outlet: Bottom.
4. Top or Strainer Material: Nickel bronze.
5. Trap Features: Trap-seal primer valve drain connection.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company; Elmdor/Stoneman Div.
 - b. Thaler Metal Industries Ltd.
2. Description: Manufactured assembly made of 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch- (1.6-mm-) thick, lead flashing collar and skirt extending at least 6 inches (150 mm) from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
 - a. Open-Top Vent Cap: Without cap.
 - b. Low-Silhouette Vent Cap: With vandal-proof vent cap.
 - c. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 (DN 15) side inlet.

B. Barrier Type Floor Drain Trap Seal Protection Device

1. An ICC-ES certified product with HDPE housing with heavy duty silicone diaphragm and soft EPDM rubber sealing gasket complying with ASSE 1072-2007

C. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

D. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches (51 mm) above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

E. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

2.5 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.

2. Vent Pipe Flashing: 3.0-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.
3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.

- B. Fasteners: Metal compatible with material and substrate being fastened.
- C. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- D. Solder: ASTM B 32, lead-free alloy.
- E. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.6 STORM SHELTER VENT PENETRATION PROTECTION

- A. Products shall be 3rd party tested to meet ICC-500 2014, impact resistant to 250+ mph.
- B. Products shall have rust resistant coating.
- C. Vent terminations through shelter roof shall be Cyclone Roof Penetration Housings, LLC model CVTR or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

- a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
 - b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
 - c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- E. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- F. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- G. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 2. Size: Same as floor drain inlet.
- H. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- I. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- J. Install vent caps on each vent pipe passing through roof.
- K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness or thinner.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according other sections of the specifications.
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each grease interceptor.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319

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SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Floor drains.
 - 2. Floor sinks.
 - 3. Trench drains.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene styrene.
- B. FRP: Fiberglass-reinforced plastic.
- C. HDPE: High-density polyethylene.
- D. PE: Polyethylene.
- E. PP: Polypropylene.
- F. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

- A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary piping specialty components.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Standard: ASME A112.6.3.
2. Pattern: Floor drain.
3. Body Material: Gray iron.
4. Outlet: Bottom.
5. Top or Strainer Material: Bronze.
6. Top of Body and Strainer Finish: Nickel bronze.
7. Top Shape: As scheduled on the plans.
8. Top Loading Classification: Light Duty.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks:

1. Standard: ASME A112.6.7.
2. Pattern: Floor drain.
3. Body Material: Cast iron.
4. Outlet: Bottom connection.
5. Coating on Interior Surfaces: Acid-resistant enamel.
6. Internal Strainer: Dome.
7. Internal Strainer Material: Aluminum.
8. Top Grate Material: Cast iron.
9. Top of Body and Grate Finish: Nickel bronze.
10. Top Shape: Square.

2.4 TRENCH DRAINS

A. Trench Drains:

1. Standard: ASME A112.6.3 for trench drains.
2. Material: Polypropylene.
3. Grate Material: Galvanized Steel or Ductile iron

PART 3 - EXECUTION

3.1 INSTALLATION

- #### A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 3. Set with grates depressed according to the following drainage area radii:

- a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
 - b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
 - c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
 4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- B. Install trench drains at low points of surface areas to be drained.
1. Set grates of drains flush with finished surface, unless otherwise indicated.
 2. Install on support devices, so that top will be flush with adjacent surface.

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements in Section 221319 "Sanitary Waste Piping Specialties" for backwater valves, air admittance devices and miscellaneous sanitary drainage piping specialties.
- C. Install piping adjacent to equipment to allow service and maintenance.

3.3 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221319.13

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SECTION 221323 - SANITARY WASTE INTERCEPTORS

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. Grease interceptors.
 - 2. Oil interceptors

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of interceptor indicated.
- B. Shop Drawings: For each type and size of precast-concrete interceptor indicated.

PART 2 - PRODUCTS

2.1 OIL INTERECEPTORS

- A. Construction:
 - 1. Oil separator shall be lifetime guaranteed and made in the USA.
 - 2. Separator shall be constructed of polyethylene with 7/8" nominal wall thickness.
 - 3. Separator shall be manufactured for below-grade installation.
 - 4. Field-adjustable riser system is available as an option to bring manhole covers to
 - 5. grade.
 - 6. Covers shall be H20 rated pickable cast iron.
 - 7. Separator shall be certified to IAPMO IGC 183-2016 and carry a UPC listing.
- B. Capacities and Characteristics: As indicated in the schedule on the plans.

2.2 MANHOLE RISERS

- A. Provide field-cut adjustable riser system as required to extend manhole access to covers flush with grade. Riser to consist of injection molded polypropylene body, 100% Silicone Sealant for

assembly of riser components, butyl mastic sealant for tank-riser or riser-riser joints, stainless steel fastening hardware and heavy duty nylon cable ties and mounts.

- B. Riser shall allow field adjustability of cover to grade.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in other sections of these specifications.

3.2 INSTALLATION

- A. Install interceptors according to manufacturer's instructions and certifications. Set level and plumb.
- B. Install manhole risers from top of underground interceptors to manholes and covers at finished grade.
- C. Set tops of manhole frames and covers flush with finished surface in pavements.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 221316 "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

- A. Identification materials and installation are specified in other sections of these specifications. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
 - 1. Use warning tapes or detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

END OF SECTION 221323

SECTION 221413 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following storm drainage piping inside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.
 - 3. Encasement for underground metal piping.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit 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. Pipe installation, indicating coordination with general construction, building components including structure, HVAC equipment and ductwork, sprinkler piping, electrical panels, service and conduits, cable trays, and other building services. Indicate proposed changes to pipe layout.
 - 2. Suspended ceiling components.
 - 3. Size and location of access to concealed valves and equipment.
 - 4. Penetrations of smoke barriers and fire-rated construction.
- B. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.4 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
 - 1. Storm Drainage Piping: 30-foot head of water.

1.5 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
- B. Shielded Couplings: Assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
 - 1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With 304 stainless-steel shield, 304 stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

2.3 PVC PIPE AND FITTINGS

- A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- C. 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."
- D. 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."

PART 3 - EXECUTION

- 3.1 With the approval of the local jurisdiction, plastic piping as specified may be used and where located in return air plenums shall be wrapped with noncombustible insulation listed for plenum installation with a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84.

3.2 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in other sections of these specifications.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations from layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. 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.
- I. Lay buried building storm 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.
- J. Install storm drainage piping at the following minimum slopes unless otherwise indicated:

1. Building Storm Drain: 1 percent downward in direction of flow unless noted otherwise on the plans.
 2. Horizontal Storm-Drainage Piping: 1 percent downward in direction of flow unless noted otherwise on the plans.
- K. 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.
- L. Install aboveground PVC piping according to ASTM D 2665.
- M. Install underground PVC piping according to ASTM D 2321.
- N. Plumbing Specialties:
1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
 2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."
- O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors.
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.4 JOINT CONSTRUCTION

- A. 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.
- B. Plastic, Nonpressure-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. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 3. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 Appendixes.

3.5 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in OD's.
2. In Drainage Piping: Shielded, nonpressure transition couplings.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 3. Vertical Piping: MSS Type 8 or Type 42, clamps.
 4. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 6. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
 6. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 and NPS 8 (DN 150 and DN 200): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
5. NPS 10 and NPS 12 (DN 250 and DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

- H. Install supports for vertical ABS and PVC piping every 48 inches (1200 mm).
- I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.
1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

3.8 IDENTIFICATION

- A. Identify storm drainage piping. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping 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 storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure: Test storm drainage piping 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 (30 kPa). From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.

3.10 CLEANING

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

3.1 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints. Where installed in plenums, wrap with noncombustible insulation listed for plenum installation.
- C. Underground storm drainage piping shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy duty hubless-piping couplings; and coupled joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 221413

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SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Roof drains.
 - 2. Miscellaneous storm drainage piping specialties.
 - 3. Cleanouts.
 - 4. Flashing materials.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Josam Company; Josam Div.
 - 2. MIFAB, Inc.
 - 3. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - 4. Tyler Pipe; Wade Div.
 - 5. Wade
 - 6. Watts Drainage Products Inc.
 - 7. Zurn Plumbing Products Group; Light Commercial Operation.
 - 8. Zurn Plumbing Products Group; Specification Drainage Operation.

2.2 METAL ROOF DRAINS

A. Cast-Iron General-Purpose Roof Drains:

1. Standard: ASME A112.6.4, for general-purpose roof drains.
2. Body Material: Cast iron.
3. Dimension of Body: Nominal 14-inch diameter.
4. Outlet: Bottom.
5. Underdeck Clamp: Required.
6. Sump Receiver Plate: Required.
7. Dome Material: Cast iron.
8. Water Dam: 2 inches high (on overflow drains only).

2.3 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Downspout Adaptors:

1. Description: Manufactured, gray-iron casting, for attaching to horizontal-outlet, parapet roof drain and to exterior, sheet metal downspout.
2. Size: Inlet size to match parapet drain outlet.

B. Downspout Boots:

1. Description: Manufactured, ASTM A 48/A 48M, gray-iron casting, with strap or ears for attaching to building; NPS 4 (DN 100) outlet; and shop-applied bituminous coating.
2. Size: Inlet size to match downspout and NPS 4 (DN 100) outlet.

C. Downspout Nozzles:

1. Description: Bronze body with bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

2.4 CLEANOUTS

A. Floor Cleanouts:

1. Standard: ASME A112.36.2M, for threaded, adjustable housing cleanouts.
2. Size: Same as connected branch.
3. Type: Threaded, adjustable housing.
4. Body or Ferrule Material: Cast iron
5. Outlet Connection: Threaded.
6. Closure: Brass plug with tapered threads.
7. Adjustable Housing Material: Cast iron.
8. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
9. Frame and Cover Shape: Round.

B. Test Tees:

1. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301, for cleanout test tees.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or hubless, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure Plug: Countersunk.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

C. Wall Cleanouts:

1. Standard: ASME A112.36.2M, for cleanouts. Include wall access.
2. Size: Same as connected drainage piping.
3. Body Material: Hubless, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure: Countersunk plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
6. Wall Access: Round, deep, chrome-plated bronze cover plate with screw.
7. Wall Access: Round wall-installation frame and cover.

2.5 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead-free alloy.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Install expansion joints, if indicated, in roof drain outlets.

3. Position roof drains for easy access and maintenance.
- B. Install downspout adapters on outlet of back-outlet parapet roof drains and connect to sheet metal downspouts.
- C. Install downspout boots at grade with top 6 inches (152 mm) above grade. Secure to building wall.
- D. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- E. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 1. Use cleanouts the same size as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 3. Locate cleanouts at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 4. Locate cleanouts at base of each vertical stack.
- F. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- G. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- H. Install test tees in vertical conductors and near floor.
- I. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- J. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- K. Install sleeve flashing device with each conductor passing through floors with waterproof membrane.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of 6.0-lb/sq. ft. (30-kg/sq. m) lead sheets, 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of 4.0-lb/sq. ft. (20-kg/sq. m) lead sheets, 0.0625-inch (1.6-mm) thickness or thinner.
 2. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
1. Pipe Flashing: Sleeve type, matching the pipe size, with a minimum length of 10 inches (250 mm) and with skirt or flange extending at least 8 inches (200 mm) around pipe.
 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

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SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Submersible sump pumps.
 - 2. Sump-pump basin covers.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. All pumps must have a pump efficiency index (PEI) less than or equal to one where required per DOE regulations.
- 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 Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.

- C. Comply with pump manufacturer's written rigging instructions for handling.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.
 - 2. Warranty shall include a 1 year labor warranty.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

- A. Submersible, Fixed-Position, Single-Seal Sump Pumps:
 - 1. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 - a. Bell & Gossett Domestic Pump; ITT Corporation.
 - b. Ebara
 - c. Goulds Pumps; ITT Corporation.
 - d. Grundfos Pumps Corp.
 - e. Weil Pump Company, Inc.
 - f. Zoeller Company.
 - 2. Description: Factory-assembled and -tested sump-pump unit.
 - 3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump.
 - 4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
 - 5. Impeller: Statically and dynamically balanced, design for clear wastewater handling, and keyed and secured to shaft.
 - 6. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
 - 7. Seal: Mechanical.
 - 8. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
- B. Controls:
 - 1. Oil smart switch and alarm panel.
 - 2. Enclosure: NEMA Type 4X wall-mounted 115 V single phase control panel with:
 - a. 20 foot piggyback electrical supply cord
 - b. Audible and light alarms with dry contacts

- c. Preset 'on' and 'off' points and ability to differentiate oil and water
- d. Alarm test and silence switches
- e. 304 Stainless steel probes
- f. UL508 approved switch

3. Control-Interface Features:

- a. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.

2.2 SUMP PUMP CAPACITIES AND CHARACTERISTICS

- A. As indicated on the equipment schedule on the plans.

2.3 SUMP-PUMP BASIN COVERS

- A. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
- B. Capacities and Characteristics:
 - 1. As indicated on the equipment schedule on the plans.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors appropriate for the proposed service.
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for plumbing piping to verify actual locations of piping connections before sump pump installation.

3.2 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

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.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Pumps and controls will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 ADJUSTING

- A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust control set points.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps.

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SECTION 221513 - GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes piping and related specialties for general-service compressed-air systems operating at 200 psig (1380 kPa) or less.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. CR: Chlorosulfonated polyethylene synthetic rubber.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. HDPE: High-density polyethylene plastic.
- E. NBR: Acrylonitrile-butadiene rubber.
- F. PE: Polyethylene plastic.
- G. PVC: Polyvinyl chloride plastic.
- H. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig (1035 kPa) or less.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Dielectric fittings.
 - 2. Flexible pipe connectors.
 - 3. Safety valves.
 - 4. Pressure regulators. Include rated capacities and operating characteristics.
 - 5. Automatic drain valves.
 - 6. Filters. Include rated capacities and operating characteristics.
 - 7. Lubricators. Include rated capacities and operating characteristics.
 - 8. Quick couplings.

9. Hose assemblies.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

2.2 Rigid Aluminum Pipe

- A. The pipe shall be rigid and manufactured in Aluminum of AW-6060 T51 or AW-6063 T5 as defined in ASTM B241. It shall be extruded and calibrated within the tolerances for specific diameters of the Parker Transair® fittings. The pipe has been qualified, as defined by ISO 9001-2015, to warranty gripping and leak-tight performance of the system.
- B. The pipe shall be blue powder coated in RAL 5012 with Qualicoat to warranty mechanical, physical, and chemical properties.
- C. Markings on the pipe will indicate the Transair® brand, the internal and external dimensions, batch number and Country of Origin. The pipe shall also have two marker lines at angle of 0° and 90° to indicate drilling positions for take-off connector.
- D. Fittings
 1. (1/2"), (1") and (1-1/2")
 - a. All connectors shall be instant connection by means of a gripping ring technology with a half turn release nut mechanism. They must have a visual torque indicator to guarantee the correct installation of the fittings. They shall incorporate a lateral dismantling feature for the rigid pipe. The connectors shall be manufactured in engineering grade polymer (PA 6.6 or PA 12; both with 30% fiberglass reinforcement) with gripping teeth manufactured in stainless steel Z10 CN 17-7E2 (AISI 301) and with seals of NBR70 nitrile with an IRHD50.
 2. (2") and (2-1/2")
 - a. All connectors use a Snap Ring technology with a threaded release nut mechanism. They shall incorporate a lateral dismantling feature for the rigid pipe. The connectors shall be manufactured in black cathodized aluminum AS9U3 with a snap ring manufactured in PA 6.6 or PA 12; both with 50% fiberglass reinforcement.
 3. (3") and (4")

- a. All connectors fittings shall be formed from 304 Stainless Steel and conform to ASTM A774 specifications. All fittings shall be connected using clamshell and cartridge technology with a reusable mechanical connection. The clamshell shall be manufactured of Zinc treated steel with the seal cartridge manufactured in engineering grade polymer with seals of NBR70 nitrile IRHD50.

2.3 VALVES

- A. As recommended by the piping manufacturer.

2.4 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. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig (860 kPa) minimum at 180 deg F (82 deg C).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

2.5 FLEXIBLE PIPE CONNECTORS

- A. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 1. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
 2. End Connections, NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
 3. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
- B. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
 1. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
 2. End Connections, NPS 2 (DN 50) and Smaller: Threaded steel pipe nipple.
 3. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.6 SPECIALTIES

- A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.

1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.
- B. Air-Main Pressure Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig (1725-kPa) inlet pressure, unless otherwise indicated.
 1. Type: Pilot operated.
- C. Air-Line Pressure Regulators: Diaphragm operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 200-psig (1380-kPa) minimum inlet pressure, unless otherwise indicated.
- D. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is indicated.
- E. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded. Include mounting bracket if wall mounting is indicated.
- F. Mechanical Filters: Two-stage, mechanical-separation-type, air-line filters. Equip with deflector plates, resin-impregnated-ribbon-type filters with edge filtration, and drain cock. Include mounting bracket if wall mounting is indicated.
- G. Air-Line Lubricators: With drip chamber and sight dome for observing oil drop entering air stream; with oil-feed adjustment screw and quick-release collar for easy bowl removal. Include mounting bracket if wall mounting is indicated.
 1. Provide with automatic feed device for supplying oil to lubricator.

2.7 QUICK COUPLINGS

- A. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.
- B. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
 1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
 2. Plug End: Straight-through type with barbed outlet for attaching hose.
- C. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.
 1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
 2. Plug End: With barbed outlet for attaching hose.

2.8 HOSE ASSEMBLIES

- A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig (2070-kPa) minimum working pressure, unless otherwise indicated.
 - 1. Hose: Reinforced double-wire-braid, CR-covered hose for compressed-air service.
 - 2. Hose Clamps: Stainless-steel clamps or bands.
 - 3. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
 - 4. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Low-Pressure Compressed-Air Distribution Piping: Use the following piping materials for all sizes:
 - 1. Rigid aluminum piping.
- B. Drain Piping: Use the following piping materials:
 - 1. NPS 2 (DN 50) and Smaller: PVC pipe and fittings; and solvent-cemented joints.

3.2 VALVE APPLICATIONS

- A. Metal General-Duty Valves: Comply with requirements and use valve types specified in "Valve Applications" Articles in Section 220523
 - 1. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.
- E. Install piping adjacent to equipment and machines to allow service and maintenance.
- F. Install air and drain piping with 1 percent slope downward in direction of flow.
- G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.
- H. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- I. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
- J. Install pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."
- K. Install piping to permit valve servicing.
- L. Install piping free of sags and bends.
- M. Install fittings for changes in direction and branch connections.
- N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- P. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.4 VALVE INSTALLATION

- A. General-Duty Valves: Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
- B. Install shutoff valves and unions joints at compressed-air piping to air compressors.
- C. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.
- D. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.5 FLEXIBLE PIPE CONNECTOR INSTALLATION

- A. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.
- B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.
- C. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.6 SPECIALTY INSTALLATION

- A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.
- B. Install air-main pressure regulators in compressed-air piping at or near air compressors.
- C. Install air-line pressure regulators in branch piping to equipment and tools.
- D. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.
- E. Install coalescing filters in compressed-air piping at or near air compressors and upstream from mechanical filters.
- F. Install mechanical filters in compressed-air piping at or near air compressors and downstream from coalescing filters.
- G. Install air-line lubricators in branch piping to machine tools.
- H. Install quick couplings at piping terminals for hose connections.
- I. Install hose assemblies at hose connections.

3.7 CONNECTIONS

- A. Install unions or removable joints, in piping adjacent to each valve and at final connection to each piece of equipment and machine.

3.8 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- C. Vertical Piping: MSS Type 8 or 42, clamps.

- D. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 Feet (30 m) or Less: MSS Type 1, adjustable, steel clevis hangers.
 - 2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
- E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- F. Base of Vertical Piping: MSS Type 52, spring hangers.
- G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
- H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- I. Install hangers for tubing with the following maximum horizontal spacing and minimum rod diameters unless otherwise recommended by the manufacturer:
 - 1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - 3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - 4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - 5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - 6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - 7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
 - 8. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
 - 9. NPS 3 (DN 80): 14 feet (4.3 m) with 1/2-inch (13-mm) rod.
- J. Install supports for vertical tubing every 10 feet (3 m).

3.9 LABELING AND IDENTIFICATION

- A. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment."

3.10 FIELD QUALITY CONTROL

- A. Perform field tests and inspections.
- B. Tests and Inspections:
 - 1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 150 psig (1035 kPa). Isolate test source and let stand for four hours to

- equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 - 2. Repair leaks and retest until no leaks exist.
 - 3. Inspect filters, lubricators, and pressure regulators for proper operation.
- C. Prepare test reports.

END OF SECTION 221513

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SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Commercial, electric, storage water heaters.
 - 2. Electric, tankless, domestic-water heaters.
 - 3. Water heater accessories.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated.
- B. Shop Drawings:
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- B. Source quality-control reports.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- C. ASME Compliance:
 - 1. Storage tanks of 120 gallon capacity or greater, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Electric, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Three years.
 - 2) Controls and Other Components: Three years.
 - b. Compression Tanks: Five years.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 COMMERCIAL, ELECTRIC, DOMESTIC-WATER HEATERS

- A. Commercial, Electric, Storage, Water Heaters:
 - 1. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 - a. Bradford White Corporation.
 - b. Lochinvar Corporation.
 - c. Rheem Manufacturing Company.
 - d. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 - e. State Industries.

2. Standard: UL 1453.
 3. Storage-Tank Construction: Horizontal or vertical arrangement as shown on the plans.
 - a. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.
 4. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Replaceable MAGNESIUM.
 - b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - c. Insulation: Comply with ASHRAE/IESNA 90.1.
 - d. Jacket: Steel with enameled finish.
 - e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 - f. Temperature Control: Adjustable thermostat.
 - g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 - h. Relief Valves: ASME rated and stamped for combination temperature-and-pressure relief valves. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 5. Special Requirements: NSF 5 construction.
- B. Electric, Tankless, Domestic-Water Heaters:
1. Standard: UL 499 for electric, tankless, (domestic-water heater) heating appliance.
 2. Construction: Copper piping or tubing complying with NSF 61 Annex G barrier materials for potable water, without storage capacity.
 - a. Connections: ASME B1.20.1 pipe thread.
 - b. Pressure Rating: 150 psig (1035 kPa).
 - c. Heating Element: Resistance heating system.
 - d. Temperature Control: Thermostat.
 - e. Safety Control: High-temperature-limit cutoff device or system.
 - f. Jacket: Aluminum or steel with enameled finish or plastic.
 3. Support: Bracket for wall mounting.
 4. Capacity and Characteristics: See the equipment schedules on the plans.

2.2 WATER HEATER ACCESSORIES

A. Water Compression Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL Inc.
 - b. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 - c. State Industries.
 - d. Taco, Inc.
2. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.
3. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
4. Capacity and Characteristics:
 - a. Working-Pressure Rating: 100 psig (690 kPa).
 - b. Capacity Acceptable: As indicated on the plans

B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.

C. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1.

D. Pressure-Reducing Valves: ASSE 1003 for water. Set at 25-psig- (172.5-kPa-) maximum outlet pressure unless otherwise indicated.

E. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

F. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.

G. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

2.3 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test water heaters to minimum of one and one-half times pressure rating before shipment.
- C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base.
 - 1. Exception: Omit concrete bases for commercial, electric, domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.
 - 3. Arrange units so controls and devices that require servicing are accessible.
 - 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 8. Anchor domestic-water heaters to substrate.
- C. Electric, Tankless, Domestic-Water Heater Mounting: Install electric, tankless, domestic-water heaters at least 12 inches (457 mm) above floor on wall bracket.
 - 1. Maintain manufacturer's recommended clearances.
 - 2. Arrange units so controls and devices that require servicing are accessible.
 - 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.
 - 5. Anchor domestic-water heaters to substrate.

- D. Install electric water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
 - 1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Section 220523 "General-Duty Valves for Plumbing Piping."
- E. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for electric, domestic-water heaters that do not have tank drains.
- G. Install thermometers on outlet piping of electric, domestic-water heaters.
- H. Install piping-type heat traps on inlet and outlet piping of electric, water heater storage tanks without integral or fitting-type heat traps.
- I. Fill electric, water heaters with water.
- J. Charge water compression tanks with air.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.
- C. Install balancing valves at the end of each hot water recirculation line and other locations as required to balance the recirculation system flow.
 - 1. Install balancing valves in locations where they can easily be adjusted.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Prepare test and inspection reports.

END OF SECTION 223300

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SECTION 224000 - PLUMBING FIXTURES

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 conventional plumbing fixtures and related components:
 - 1. Faucets for lavatories and sinks.
 - 2. Toilet seats.
 - 3. Protective shielding guards.
 - 4. Fixture supports.
 - 5. Water closets.
 - 6. Urinals.
 - 7. Lavatories.
 - 8. Service sinks.
 - 9. Multi-Station Wash Fountains
 - 10. Showers
- B. Related Sections include the following:
 - 1. Section 221119 "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.5 WARRANTY

- A. Manufacturer's standard form in which manufacturer agrees to repair or replace fixtures, faucets, valves, or other components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Periods: 1-Year from date of Substantial Completion.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- 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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.
- D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- G. Where applicable comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - 1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - 2. Plastic Laundry Trays: ANSI Z124.6.
 - 3. Plastic Shower Enclosures: ANSI Z124.2.
 - 4. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - 5. Slip-Resistant Bathing Surfaces: ASTM F 462.
 - 6. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 7. Stainless-Steel Residential Sinks: ASME A112.19.3.
 - 8. Vitreous-China Fixtures: ASME A112.19.2M.

9. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
 10. Water-Closet, Flushometer Tank Trim: ASSE 1037.
- H. Where applicable comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
 2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
 3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 4. Faucets: ASME A112.18.1.
 5. Hose-Connection Vacuum Breakers: ASSE 1011.
 6. Hose-Coupling Threads: ASME B1.20.7.
 7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 8. NSF Potable-Water Materials: NSF 61.
 9. Pipe Threads: ASME B1.20.1.
 10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 11. Supply Fittings: ASME A112.18.1.
- I. Brass Waste Fittings: ASME A112.18.2. Comply with the following applicable standards and other requirements specified for bathtub, bathtub/shower, and shower faucets:
1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
 2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
 3. Faucets: ASME A112.18.1.
 4. Hand-Held Showers: ASSE 1014.
 5. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
 6. Hose-Coupling Threads: ASME B1.20.7.
 7. Manual-Control Antiscald Faucets: ASTM F 444.
 8. Pipe Threads: ASME B1.20.1.
 9. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
 10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 11. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
- J. Where applicable comply with the following applicable standards and other requirements specified for miscellaneous fittings:
1. Atmospheric Vacuum Breakers: ASSE 1001.
 2. Brass and Copper Supplies: ASME A112.18.1.
 3. Dishwasher Air-Gap Fittings: ASSE 1021.
 4. Manual-Operation Flushometers: ASSE 1037.
 5. Plastic Tubular Fittings: ASTM F 409.
 6. Brass Waste Fittings: ASME A112.18.2.
 7. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
- K. Where applicable comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Disposers: ASSE 1008 and UL 430.
2. Dishwasher Air-Gap Fittings: ASSE 1021.
3. Flexible Water Connectors: ASME A112.18.6.
4. Grab Bars: ASTM F 446.
5. Hose-Coupling Threads: ASME B1.20.7.
6. Hot-Water Dispensers: ASSE 1023 and UL 499.
7. Off-Floor Fixture Supports: ASME A112.6.1M.
8. Pipe Threads: ASME B1.20.1.
9. Plastic Toilet Seats: ANSI Z124.5.
10. Supply and Drain Protective Shielding Guards: ICC A117.1.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. See Plumbing Fixture Schedule on plans for required fixtures for this project.

2.2 LAVATORY FAUCETS

- A. Lavatory Faucets:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Sloan
 2. Description: Battery powered, sensor operated.

2.3 TOILET SEATS

- A. Toilet Seats :
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard Companies, Inc.
 - b. Bemis Manufacturing Company.
 - c. Church Seats.
 - d. Comfort Seats.
 - e. Eljer.
 - f. Kohler Co.
 - g. Toto
 - h. Olsonite Corp.
 2. Description: Toilet seat for water-closet-type fixture.

- a. Material: Molded, solid plastic with antimicrobial agent.
- b. Configuration: Open front without cover.
- c. Hinge Type: SC, self-sustaining, check.

2.4 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Piping Covers:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Engineered Brass Co.
 - b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
 - c. McGuire Manufacturing Co., Inc.
 - d. Plumberex Specialty Products Inc.
 - e. TCI Products.
 - f. TRUEBRO, Inc.
 - g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.
- 2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.5 WATER CLOSETS

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

- 1. American Standard Companies, Inc.
- 2. Crane Plumbing, L.L.C./Fiat Products.
- 3. Eljer.
- 4. Kohler Co.
- 5. Sloan
- 6. Toto
- 7. Zurn Plumbing Products Group; Commercial Brass Operation.

B. Water Closets: Wall mounted, top spud.

- 1. Refer to plan for specification of fixture including height, accessories, etc.
- 2. Bowl:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Type: Siphon jet.
 - d. Style: Flushometer valve.
 - e. Height: Standard.
 - f. Rim Contour: Elongated.
 - g. Water Consumption: 1.28 gal. per flush.

- h. Spud Size and Location: NPS 1-1/2 (DN 40); top.

2.6 WATER CLOSET FLUSHOMETER VALVES

A. Flushometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Sloan Valve Company.
2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Style: Battery powered, sensor operated.
8. Consumption: 1.28 gal. (4.8 L) per flush.
9. Minimum Inlet: NPS 1 (DN 25).
10. Minimum Outlet: NPS 1-1/4 (DN 32).

2.7 URINALS

A. Urinals:

1. Refer to plan for specification of fixture including accessories, etc.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard Companies, Inc.
 - b. Crane Plumbing, LLC/Fiat Products.
 - c. Eljer.
 - d. Kohler Co.
 - e. Sloan
 - f. Toto
 - g. Zurn Plumbing Products Group; Commercial Brass Operation.
3. Fixture:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Strainer or Trapway: Manufacturer's standard strainer with integral trap.
 - d. Water Consumption: Water saving.
 - e. Spud Size and Location: NPS 3/4 (DN 20); top.
 - f. Outlet Size and Location: NPS 2 (DN 50); back.
 - g. Color: White.

4. Waste Fitting:

- a. Standard: ASME A112.18.2/CSA B125.2 for coupling.
- b. Size: NPS 2 (DN 50).

2.8 URINAL FLUSHOMETER VALVES

A. Flushometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Sloan Valve Company.
2. Standard: ASSE 1037.
3. Minimum Pressure Rating: 125 psig (860 kPa).
4. Features: Include integral check stop and backflow-prevention device.
5. Material: Brass body with corrosion-resistant components.
6. Exposed Flushometer-Valve Finish: Chrome plated.
7. Style: Battery powered, sensor operated.
8. Consumption: 0.125 gal. per flush.
9. Minimum Inlet: NPS 3/4 (DN 20).
10. Minimum Outlet: NPS 3/4 (DN 20).

2.9 LAVATORIES

A. Refer to plan for specification of fixture including size, type, accessories, etc.

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

1. American Standard Companies, Inc.
2. Crane Plumbing, L.L.C./Fiat Products.
3. Eljer.
4. Kohler Co.
5. Sloan
6. Toto
7. Zurn Plumbing Products Group; Commercial Brass Operation.

C. Fixture:

1. Standard: ASME A112.19.2/CSA B45.1.
2. Faucet-Hole Location: Top.
3. Color: White.
4. Mounting Material: Sealant.

2.10 SERVICE SINKS

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

1. American Standard Companies, Inc.
2. Crane Plumbing, L.L.C./Fiat Products.
3. Eljer.
4. Fiat.
5. Florestore Products Co., Inc.
6. Kohler Co.
7. Stern-Williams Co., Inc.

2.11 FIXTURE SUPPORTS

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

1. Josam Company.
2. Smith, Jay R. Mfg. Co.
3. Wade
4. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
5. Zurn Plumbing Products Group; Specification Drainage Operation.

- B. Water-Closet Supports:

1. Description: Extra Heavy Duty combination carrier to support minimum 750 lbs, designed for wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, compact or regular, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

- C. Urinal Supports:

1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

- D. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

2.12 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF/ANSI 61, "Drinking Water System Components - Health Effects," for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Loose key.
- F. Risers:
 - 1. NPS 1/2 (DN 15)
 - 2. ASME A112.18.6, braided or corrugated stainless-steel flexible hose.

2.13 WASH FOUNTAINS (WF)

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bradley Corp.
 - 2. Acorn Engineering.

2.14 SHOWER FAUCETS

- A. NSF Standard: Comply with NSF 61 Annex G, "Drinking Water System Components - Health Effects," for shower materials that will be in contact with potable water.
- B. Shower Faucets:
 - 1. Description: Single-handle, pressure-balance mixing valve with hot- and cold-water indicators; check stops; and shower head.
 - 2. Faucet:
 - a. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016.
 - b. Body Material: Solid brass.
 - c. Finish: Polished chrome plate.
 - d. Mounting: Concealed.
 - e. Operation: Single-handle, push-pull or twist or rotate control.
 - f. Antiscald Device: Integral with mixing valve or Separate unit.
 - g. Check Stops: Check-valve type, integral with or attached to body; on hot- and cold-water supply connections.

3. Supply Connections: NPS 1/2 (DN 15).
4. Shower Head:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Type: Ball joint with arm and flange.
 - c. Shower Head Material: Metallic with chrome-plated finish.
 - d. Spray Pattern: Adjustable.
 - e. Temperature Indicator: Not required.
5. Vacuum Breakers: Provide vacuum breakers on hand held shower heads.

2.15 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/2 (DN 40) offset and straight tailpiece.
- C. Trap:
 1. Size: NPS 1-1/2 (DN 40).
 2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- (0.83-mm-) thick brass tube to wall; and chrome-plated brass or steel wall flange.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all fixtures, material, accessories, etc. according to the manufacturer's instructions.

3.2 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 WATER CLOSET INSTALLATION

- A. Water-Closet Installation:
 1. Install level and plumb according to roughing-in drawings.

2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Support Installation:

1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
2. Use carrier supports with waste-fitting assembly and seal.
3. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.

C. Flushometer-Valve Installation:

1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
4. Install actuators in locations that are easy for people with disabilities to reach.

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.

3.4 URINAL INSTALLATION

A. Urinal Installation:

1. Install urinals level and plumb according to roughing-in drawings.
2. Install wall-hung, back-outlet urinals onto waste fitting seals and attached to supports.
3. Install wall-hung, bottom-outlet urinals with tubular waste piping attached to supports.
4. Install accessible, wall-mounted urinals at mounting height for the handicapped/elderly, according to ICC/ANSI A117.1.
5. Install trap-seal liquid in waterless urinals.

B. Support Installation:

1. Install supports, affixed to building substrate, for wall-hung urinals.

2. Use off-floor carriers with waste fitting and seal for back-outlet urinals.
3. Use carriers without waste fitting for urinals with tubular waste piping.
4. Use chair-type carrier supports with rectangular steel uprights for accessible urinals.

C. Flushometer-Valve Installation:

1. Install flushometer-valve water-supply fitting on each supply to each urinal.
2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
3. Install lever-handle flushometer valves for accessible urinals with handle mounted on open side of compartment.
4. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

D. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.

E. Joint Sealing:

1. Seal joints between urinals and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to urinal color.

3.5 LAVATORY INSTALLATION

- A. Install lavatories level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.
- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.
- E. Seal joints between lavatories and counters and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.6 SHOWER INSTALLATION

- A. Assemble shower components according to manufacturers' written instructions.
- B. Install showers level and plumb according to roughing-in drawings.

- C. Install water-supply piping with stop on each supply to each shower faucet.
 - 1. Exception: Use ball or gate valves if supply stops are not specified with shower. Comply with valve requirements specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
 - 2. Install stops in locations where they can be easily reached for operation.
- D. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- E. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheons requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- F. Seal joints between showers and floors and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.7 GENERAL INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install floor mounted concealed arm supports, affixed to building substrate, for wall-mounting fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install counter-mounting fixtures in and attached to casework.
- D. Install fixtures level and plumb according to roughing-in drawings.
- E. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture.
- F. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- G. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- H. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

- I. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
- J. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- K. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- L. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings.
- M. Install brass flanges on flushometers spud connections.
- N. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color.

3.8 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste and vent piping. Use size fittings required to match fixtures.
- C. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- E. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories and sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.9 FIELD QUALITY CONTROL

- A. Operate and adjust urinals and controls. Replace damaged and malfunctioning urinals, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
- D. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

- E. Check that plumbing fixtures are complete with trim, faucets, fittings and other specified components.
- F. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- G. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.10 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.
- C. Replace washers and seals of leaking and dripping faucets and stops.
- D. Install fresh batteries in sensor-operated mechanisms.

3.11 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - 2. Remove sediment and debris from drains.
- B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.12 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224000

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SECTION 224700 - DRINKING FOUNTAINS AND WATER COOLERS

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 the following water coolers and related components:
 - 1. Pressure water coolers.
 - 2. Fixture supports.

1.3 SUBMITTALS

- A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.4 WARRANTY

- A. Manufacturer's standard form in which manufacturer agrees to repair or replace drinking fountains, water coolers, or other components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Periods: 1-Year from date of Substantial Completion.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.
- C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- D. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.
- E. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

- A. Water Coolers:
 - 1. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 - a. Elkay Manufacturing Co.
 - b. Halsey Taylor.
 - c. Haws Corporation.
 - d. Oasis Corporation.
 - 2. Description: Accessible (if indicated), ARI 1010, Type PB, pressure with bubbler, Style W, wall-mounting water cooler.
 - a. Cabinet: Single or Bi-level with two attached cabinets, all stainless steel.
 - b. Bubbler: One, with adjustable stream regulator, located on each cabinet deck.
 - c. Control: Push button or Push bar.
 - d. Supply: NPS 3/8 (DN 10) with ball, gate, or globe valve.
 - e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
 - f. Bottle Filler (where shown): Sensor activation with automatic shutoff timer. Fill rate 0.5 to 1.5 gpm.
 - g. Drain(s): Grid with NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.1.
 - h. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

- 1) Capacity: 8 gph (0.0084 L/s) of 50 deg F (10 deg C) cooled water from 80 deg F (27 deg C) inlet water and 90 deg F (32 deg C) ambient air temperature.

- i. Support: Type I or II, water cooler carrier. Refer to "Fixture Supports" Article.

2.2 FIXTURE SUPPORTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Josam Co.
 2. Smith, Jay R. Mfg. Co.
 3. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
 4. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
 1. Type I: Hanger-type carrier with two vertical uprights.
 2. Type II: Bilevel, hanger-type carrier with three vertical uprights.
 3. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.
- B. Examine walls and floors for suitable conditions where fixtures are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
- B. Use mounting frames for recessed water coolers, unless otherwise indicated.
- C. Set freestanding and pedestal drinking fountains on floor.
- D. Set remote water coolers on floor, unless otherwise indicated.

- E. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

- A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.
- B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.
- C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- F. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- G. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

- A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
 - 1. Remove and replace malfunctioning units and retest as specified above.
 - 2. Report test results in writing.

3.6 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust water cooler temperature settings.

3.7 CLEANING

- A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 224700

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SECTION 230500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Grout.
4. Equipment installation requirements common to equipment sections.
5. Concrete bases.
6. Supports and anchorages.

1.2 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: The contractor shall submit equipment and layout 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. Mechanical Systems

- a. All mechanical equipment including roof mounted, ground mounted and ceiling hung including required clearances.
- b. Suspended mechanical equipment including required clearances.
- c. Duct installation, indicating coordination with general construction, building components including structure, hydronic, plumbing, and sprinkler piping, electrical conduits, cable trays, and other building services. Indicate proposed duct sizes, elevations, changes in elevation, etc.
- d. Piping installation including hydronic, condensate, and refrigerant, indicating coordination with general construction, building components including, ductwork, structure, plumbing, and sprinkler piping, electrical conduits, cable trays, and other building services. Indicate proposed sizes, elevations, changes in elevation, etc.
- e. Suspended ceiling components.
- f. Size and location of access to concealed equipment.
- g. Penetrations of smoke barriers and fire-rated construction.

2. Hydronic Systems

- a. Mechanical Rooms: Hydronic systems equipment including chillers, boilers, pumps, air separators, expansion tanks, water treatment equipment and all other hydronic specialties, indicating coordination with general construction, building components including structure, duct, plumbing, and sprinkler piping, electrical conduits, and other building services.

- b. Building piping construction plans, indicating coordination with general construction, building components including structure, duct, plumbing, and sprinkler piping, electrical conduits, cable trays and other building services. Indicate proposed sizes, elevations, changes in elevation, etc.
 - c. Suspended ceiling components.
 - d. Size and location of access to concealed equipment.
 - e. Penetrations of smoke barriers and fire-rated construction.
- B. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.4 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Characteristics of Mechanical Material and Equipment: Material and Equipment of equal performance and similar characteristics to the basis of design material and equipment specified in the plans and in other sections of these specifications may be furnished provided such proposed equipment is approved by the engineer. The contractor is responsible for guaranteeing that the proposed material or equipment is equal in performance to the specified material and equipment under all operating conditions. All connecting electrical services, circuit breakers,

and conduit sizes are to be appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements. All costs associated with the substitution of materials and equipment or costs of replacing substituted equipment or material with material or equipment with operating characteristics equal to the specified material or equipment shall be borne by the substituting contractor.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is 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, BCuP Series or BAg1, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12.
- G. Solvent Cements for Joining Plastic Piping:
 - 1. CPVC Piping: ASTM F 493.
 - 2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.
- E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
- F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.4 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 HVAC DEMOLITION

- A. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 - 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- B. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 INSTALLATION – COMMON REQUIREMENTS

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Testing, adjusting and balancing of the mechanical systems and related ancillary equipment will be performed by a qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems are the responsibility of the Mechanical Contractor.
- C. The Mechanical Contractor shall make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm. Any changes shall keep the duct system within its design limitations with respect to the speed of the device and pressure classification of the distribution system. Material and labor costs for sheave changes are to be provided at no additional costs.

3.3 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. 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.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors whether in exposed, concealed, finished or unfinished spaces.

- M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs. Refer to section 220517.
- N. Install sleeves for pipes passing through interior partitions.
- O. Verify final equipment locations for roughing-in.
- P. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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.
- E. 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.
- F. 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.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement 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 schedule number ASTM D 1785, 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.
- 4. PVC Nonpressure Piping: Join according to ASTM D 2855.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.5 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
 - 3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 - 4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.6 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. In areas with no ceilings, install equipment to allow maximum possible headroom unless specific mounting heights are indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- D. Install equipment to allow right of way for piping installed at required slope.

3.7 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement, minimum 6" thick, as specified in other sections of these specifications.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.9 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor HVAC materials and equipment.
- B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.
- C. Attach to substrates as required to support applied loads.

3.10 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

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END OF SECTION 230500

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SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR MECHANICAL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
- D. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- E. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- A. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Carbon steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch (25-mm) annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.

- a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level.
3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
 1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Cast-iron wall sleeves, or Galvanized-steel wall sleeves.
 - 2. Exterior Concrete Walls below Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Cast-iron wall sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.
 - 4. Concrete Slabs above Grade:
 - a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.
 - 5. Interior Partitions:
 - a. Galvanized-steel-pipe sleeves or PVC-pipe sleeves.

END OF SECTION 220517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Escutcheons.
 - 2. Floor plates.

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

- A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:

- a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
- 1. New Piping: One-piece, floor-plate type.

3.2 FIELD QUALITY CONTROL

- A. Replace broken and damaged escutcheons and floor plates using new materials.

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Liquid-in-glass thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gages.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flo Fab Inc.
 - b. Miljoco Corporation.
 - c. Palmer Wahl Instrumentation Group.
 - d. Tel-Tru Manufacturing Company.
 - e. Trerice, H. O. Co.
 - f. Weiss Instruments, Inc.
 - g. Winters Instruments - U.S.
 - 2. Standard: ASME B40.200.

3. Case: Cast aluminum; 7-inch (178-mm) nominal size unless otherwise indicated.
4. Case Form: Adjustable angle unless otherwise indicated.
5. Tube: Glass with magnifying lens and blue or red organic liquid.
6. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
7. Window: Glass or plastic.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches (32 mm), with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 THERMOWELLS

- A. Thermowells:
 1. Standard: ASME B40.200.
 2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
 3. Material for Use with Copper Tubing: CNR or CUNI.
 4. Material for Use with Steel Piping: CRES.
 5. Type: Stepped shank unless straight or tapered shank is indicated.
 6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
 7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
 8. Bore: Diameter required to match thermometer bulb or stem.
 9. Insertion Length: Length required to match thermometer bulb or stem.
 10. Lagging Extension: Include on thermowells for insulated piping and tubing.
 11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

2.4 PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMETEK, Inc.; U.S. Gauge.

- b. Ernst Flow Industries.
 - c. Flo Fab Inc.
 - d. Marsh Bellofram.
 - e. Miljoco Corporation.
 - f. Terice, H. O. Co.
 - g. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
 - h. Weiss Instruments, Inc.
- 2. Standard: ASME B40.100.
 - 3. Case: Liquid-filled type; cast aluminum or drawn steel; 4-1/2-inch (114-mm) nominal diameter.
 - 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 6. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 - 8. Pointer: Dark-colored metal.
 - 9. Window: Glass.
 - 10. Ring: Metal.
 - 11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass pipe with pipe threads.
- C. Valves: Brass ball, with NPS 1/4 or NPS 1/2 (DN 8 or DN 15), ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- J. Install valve and syphon fitting in piping for each pressure gage for steam.
- K. Install permanent indicators on walls or brackets in accessible and readable positions.
- L. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler.
 - 3. Inlets and outlets of each chiller.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.
 - 5. Inlets and outlets of each hydronic heat exchanger.
 - 6. Inlet and outlet of each thermal-storage tank.
 - 7. Outside-, return-, supply-, and mixed-air ducts.
- M. Install pressure gages in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
 - 3. Suction and discharge of each pump.
 - 4. Inlet and outlet of each hydronic coil in air-handling units.

3.2 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gages to proper angle for best visibility.

3.3 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 100 deg F.
- B. Scale Range for Condenser-Water Piping: 0 to 160 deg F.
- C. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.
- D. Scale Range for Air Ducts: 0 to 100 deg F.

3.4 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range: 0 to 100 psi.

END OF SECTION 230519

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SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Bronze ball valves.
 - 2. Bronze swing check valves.
 - 3. Bronze gate valves.
 - 4. Bronze globe valves.

- B. Related Sections:

- 1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve indicated.

1.4 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance: ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to HVAC valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
 - 2. Handwheel: For valves other than quarter-turn types.
 - 3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller.
- E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
 - 1. Gate Valves: With rising stem.
 - 2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 3. Butterfly Valves: With extended neck.
- F. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Solder Joint: With sockets according to ASME B16.18.
 - 3. Threaded: With threads according to ASME B1.20.1.
 - 4. I.P.S. Grooved: with body style manufactured in accordance with MSS-SP67.

2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. Crane Co.; Crane Valve Group; Crane Valves.
 - d. Hammond Valve.
 - e. Lance Valves; a division of Advanced Thermal Systems, Inc.
 - f. Legend Valve.
 - g. Milwaukee Valve Company.
 - h. NIBCO INC.
 - i. Red-White Valve Corporation.
 - j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig (1035 kPa).
 - c. CWP Rating: 600 psig (4140 kPa).
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.

- g. Seats: PTFE or TFE.
- h. Stem: Bronze.
- i. Ball: Chrome-plated brass.
- j. Port: Full.

2.3 BRONZE SWING CHECK VALVES

A. Class 125, Bronze Swing Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Division.
 - e. Hammond Valve.
 - f. Kitz Corporation.
 - g. Milwaukee Valve Company.
 - h. NIBCO INC.
 - i. Powell Valves.
 - j. Red-White Valve Corporation.
 - k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - l. Zy-Tech Global Industries, Inc.
2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. TFE Seat Disc.

2.4 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Crane Co.; Crane Valve Group; Crane Valves.
 - c. Crane Co.; Crane Valve Group; Jenkins Valves.
 - d. Crane Co.; Crane Valve Group; Stockham Division.
 - e. Hammond Valve.
 - f. Kitz Corporation.
 - g. Milwaukee Valve Company.

- h. NIBCO INC.
- i. Powell Valves.
- j. Red-White Valve Corporation.
- k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- l. Zy-Tech Global Industries, Inc.

2. Description:

- a. Standard: MSS SP-80, Type 1.
- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
- d. Ends: Threaded or solder joint.
- e. Stem: Bronze.
- f. TFE Seat Disc.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable or ductile iron.

2.5 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Hammond Valve.
 - d. Kitz Corporation.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Powell Valves.
 - h. Red-White Valve Corporation.
 - i. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - j. Zy-Tech Global Industries, Inc.
- 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig (1380 kPa).
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded or solder joint.
 - e. Stem and Disc: Bronze.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for valves NPS 4 (DN 100) and larger and more than 72 inches above floor. Extend chains to 60 inches (1520 mm) above finished floor.
- F. Install swing check valves for proper direction of flow and in horizontal position with hinge pin level.

3.3 VALVE MAP

- A. Provide a minimum 8-1/2x11 laminated floor plan of the building indicating the locations of all water shut off valves.

3.4 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.

3.5 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly, or gate valves.
 - 2. Throttling Service: Globe valves.
 - 3. Pump-Discharge Check Valves:
 - a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze disc.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

3.6 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2 (DN 50) and Smaller:
 - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 - 2. Bronze Angle Valves: Class 125, bronze disc.
 - 3. Ball Valves: Two piece, full port, bronze with bronze trim.
 - 4. Bronze Swing Check Valves: Class 125, bronze disc.
 - 5. Bronze Gate Valves: Class 125, NRS, bronze.
 - 6. Bronze Globe Valves: Class 125, bronze disc.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Thermal-hanger shield inserts.
 - 4. Fastener systems.
 - 5. Equipment supports.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated.
 - 1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper- or epoxy-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

- #### A.
- Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

A. Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.
 - c. Flex-Strut Inc.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut Corporation; Tyco International, Ltd.
 - g. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Channels: Continuous slotted steel channel with intumed lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 PIPE STANDS

- A. Refer to details on the plans for specific products.
- B. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- C. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- D. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

2.6 PIPE POSITIONING SYSTEMS

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

2.7 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

- F. Pipe Stand Installation:
1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Saddles and shields exposed to view shall have a paint grip surface.
 - b. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use copper- or epoxy-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.

J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).

- c. Heavy (MSS Type 33): 3000 lb (1360 kg).
- 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Saddles and shields exposed to view shall have a paint grip surface.
 - 2. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 3. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 4. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
 - 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
 - 3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
- P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 230529

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Pipe labels.
 - 3. Duct labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Ceiling equipment markers

1.3 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
 - 2. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
 - 3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
 - 4. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

5. Fasteners: Stainless-steel rivets or self-tapping screws.
6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
7. Color: White lettering on black background.

- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.3 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch (3.2 mm) thick, and having predrilled holes for attachment hardware.
- B. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).
- C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
- D. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- E. Fasteners: Stainless-steel rivets or self-tapping screws.

- F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- G. Duct Label Contents: Include identification of duct service using the designations "Supply", "Return", "OSA", or "Exhaust", or abbreviations as used on Drawings, an arrow indicating flow direction, AND THE EQUIPMENT SERVING THE DUCT SYSTEM USING THE EQUIPMENT'S DRAWING DESIGNATION; e.g. "RTU-A101 SUPPLY", "TB-105", etc.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.4 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
 - 1. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 2. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.
- B. Stencil Contents: Include identification of duct service using the designations "Supply", "Return", "OSA", or "Exhaust", or abbreviations as used on Drawings, an arrow indicating flow direction, AND THE EQUIPMENT SERVING THE DUCT SYSTEM USING THE EQUIPMENT'S DRAWING DESIGNATION; e.g. "VEN-1 OSA", "FPTB-112".
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.

2.5 VALVE TAGS

- A. Brass: 1-1/2" diameter, 19 gauge thick, with 3/16" top hole for fastener, natural brass finish.
- B. Lettering: Stamped or Engraved letters; 1/4" lettering for system type, 1/2" text for valve number.
 - 1. Label valves per system type as follows:
 - a. DOMCW = Domestic cold water
 - b. DOMHW = Domestic hot water
 - c. DOMHWR = Domestic hot water recirculation
 - d. CHW = Chilled water
 - e. HW = Heating hot water
 - f. COND = Condenser water
- C. Beaded Chains: No. 6 brass, 114 mm (4-1/2") long, with locking link.
- D. Chart: Laminated, typewritten letter size list in anodized aluminum frame.

2.6 CEILING MARKERS

- A. Provide markers on ceiling grids to indicate the locations of all valves, and equipment.
- B. The marker shall be a paper dot, self-adhesive, 3/4 inch diameter.
- C. Marker colors shall be as follows:
 - 1. Valve locations: RED.
 - 2. Equipment locations: Blue.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

3.3 VALVES AND EQUIPMENT ABOVE CEILING:

- A. Provide ceiling markers on the ceiling grid nearest the lay-in ceiling tile that should be removed for access to valves and equipment above the ceiling.

3.4 PIPE LABEL INSTALLATION

- A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles, complying with ASME A13.1, on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- B. Locate pipe labels where piping is exposed in unfinished spaces 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. In each and every room or space
 - 2. Locate pipe labels on the side and top of each pipe at the intervals described below
 - 3. Near each valve and control device.

4. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
5. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
6. At access doors, manholes, and similar access points that permit view of concealed piping.
7. Near major equipment items and other points of origination and termination.
8. Spaced at maximum intervals of 10 feet along each run. Reduce intervals to 5 feet in areas of congested piping and equipment.

C. Pipe Label Color Schedule, Per ANSI / ASME Standards:

1. Heating Water Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.
2. Refrigerant Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.

3.5 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 1. Blue: For cold-air supply ducts.
 2. Yellow: For return-air ducts.
 3. Green: For exhaust-, outside-, relief-, and mixed-air ducts.
 4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
- B. Stenciled Duct Label Option: Stenciled labels, including identification of duct service using same designations or abbreviations as used on Drawings, an arrow indicating flow direction, and the equipment serving the duct system using the equipment's plan designation, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch (25 mm) high is needed for proper identification because of distance from normal location of required identification.
- C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 10 Feet in each space where ducts are exposed or concealed by removable ceiling system. Reduce intervals to 5 feet in areas of congested, duct, piping and equipment. Do not label exposed ducts in normally occupied spaces.
- D. Label ducts on the bottom and on the side at intervals described above.

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.

3.7 VALVE MAP

- A. Provide a minimum 8-1/2x11 laminated floor plan of the building indicating the locations of all water shut off valves.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

- A. Certified TAB reports at the completion of final TAB.

1.5 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 who is 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.
 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 TAB contractor's forms approved by Engineer, Construction Manager and/or Commissioning Authority.
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 SCOPE

- A. Testing, adjusting and balancing of the mechanical systems and related ancillary equipment will be performed by a qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems are the responsibility of the Mechanical Contractor.
- B. The Mechanical Contractor shall make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm. Any changes shall keep the duct system within its design limitations with respect to the speed of the device and pressure classification of the distribution system. Material and labor costs for sheave changes are to be provided at no additional costs.

3.2 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 locations of 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 system and equipment controls.
- E. Examine plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts and are properly separated from adjacent areas. Verify that penetrations in plenum walls 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 cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.

- P. 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.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:
 - 1. Equipment and systems to be tested.
 - 2. Strategies and step-by-step procedures for balancing the systems.
 - 3. Instrumentation to be used.
 - 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
 - 1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.
 - 2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning per the sequence of operation.
 - g. Shutoff and balance valves have been verified to be 100 percent open.
 - h. Pumps are started and proper rotation is verified.
 - i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - j. Variable-frequency controllers' startup is complete and safeties are verified.
 - k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111 or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
 - 1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Install and join new insulation that matches removed materials.
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes 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 occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

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

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.

- b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- 6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
- 7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
- 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
- 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
2. Measure pump TDH as follows:
 - 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 prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage 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 valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

C. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

- D. For systems with pressure-independent valves at terminals:
 - 1. Measure differential pressure and verify that it is within manufacturer's specified range.
 - 2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - 1. Measure and balance coils by either coil pressure drop or temperature method.
 - 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
 - 1. Re-measure and confirm that total water flow is within design.
 - 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - 3. Mark final settings.
- G. Verify that memory stops have been set.

3.10 PROCEDURES FOR BOILERS

- A. Hydronic Boilers:
 - 1. Measure and record entering- and leaving-water temperatures.
 - 2. Measure and record water flow.
 - 3. Measure and record pressure drop.
 - 4. Measure and Record relief valve(s) pressure setting.
 - 5. Capacity: Calculate in Btu/h (kW) of heating output.
 - 6. Fuel Consumption: If boiler fuel supply is equipped with flow meter, measure and record consumption.
 - 7. Efficiency: Calculate operating efficiency for comparison to submitted equipment.
 - 8. Fan, motor, and motor controller operating data.

3.11 CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Verify temperature control system is operating within the design limitations.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 - 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.12 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.
 - 2. Air Outlets and Inlets: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.
 - 3. Heating-Water Flow Rate: Plus 10 percent or minus 5 percent. If design value is less than 10 gpm, within 10 percent.

3.13 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare biweekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.14 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
 2. Name and address of the TAB contractor.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water and steam flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- E. Include temperature test reports for both heating and cooling modes of operation for all heating and cooling air moving equipment.
- F. Air-Handling-Unit Test Reports: For air-handling units including packaged unitary equipment, fan coils, blower coils, heat pumps etc. with coils, include the following:
1. Unit Data:

- a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches (mm), and bore.
 - i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
3. Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Filter static-pressure differential in inches wg (Pa).
 - f. Preheat-coil static-pressure differential in inches wg (Pa).
 - g. Cooling-coil static-pressure differential in inches wg (Pa).
 - h. Heating-coil static-pressure differential in inches wg (Pa).
 - i. Outdoor airflow in cfm (L/s).
 - j. Return airflow in cfm (L/s).
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
 - m. Entering air temperatures.
 - n. Leaving air temperatures.
- G. Gas-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
 1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Fuel type in input data.
 - g. Output capacity in Btu/h (kW).

- h. Ignition type.
 - i. Burner-control types.
 - j. Motor horsepower and rpm.
 - k. Motor volts, phase, and hertz.
 - l. Motor full-load amperage and service factor.
 - m. Sheave make, size in inches (mm), and bore.
 - n. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - 2. Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm (L/s).
 - b. Entering-air temperature in deg F (deg C).
 - c. Leaving-air temperature in deg F (deg C).
 - d. Air temperature differential in deg F (deg C).
 - e. Entering-air static pressure in inches wg (Pa).
 - f. Leaving-air static pressure in inches wg (Pa).
 - g. Air static-pressure differential in inches wg (Pa).
 - h. Low-fire fuel input in Btu/h (kW).
 - i. High-fire fuel input in Btu/h (kW).
 - j. Manifold pressure in psig (kPa).
 - k. High-temperature-limit setting in deg F (deg C).
 - l. Operating set point in Btu/h (kW).
 - m. Motor voltage at each connection.
 - n. Motor amperage for each phase.
 - o. Heating value of fuel in Btu/h (kW).
- H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches (mm), and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).
- I. Round, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated air flow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual air flow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).
- J. Air-Terminal-Device Reports:
 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft. (sq. m).
 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary air flow rate as needed in cfm (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final air flow rate in cfm (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Entering air temperatures in deg F (deg C).
 - h. Leaving air temperatures in deg F (deg C).
 - i. Space temperature in deg F (deg C).

K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm (L/s).
 - g. Water pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump rpm.
 - j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig (kPa).
 - b. Pump shutoff pressure in feet of head or psig (kPa).
 - c. Actual impeller size in inches (mm).
 - d. Full-open flow rate in gpm (L/s).
 - e. Full-open pressure in feet of head or psig (kPa).
 - f. Final discharge pressure in feet of head or psig (kPa).
 - g. Final suction pressure in feet of head or psig (kPa).
 - h. Final total pressure in feet of head or psig (kPa).
 - i. Final water flow rate in gpm (L/s).
 - j. Voltage at each connection.
 - k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.15 INSPECTIONS

A. Initial Inspection:

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/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - 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 Construction Manager.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Construction Manager.
3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
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 make adjustments. 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 final payment.

D. Prepare test and inspection reports.

3.16 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

METROPOLITAN CC LONGVIEW AUTOMOTIVE INSTITUTE
METROPOLITAN COMMUNITY COLLEGE
LEE'S SUMMIT, MO

13-23128-00
9 FEBRUARY 2024
BID SET

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing 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.

1.5 DEFINITIONS

- A. Supply Air: Air delivered below 60° F or above 80° F.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in the insulation schedule on the plans for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290..
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Friendly Feel Duct Wrap.
 - d. Owens Corning; SOFTR All-Service Duct Wrap.
- E. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied ASJ.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.
- F. Elastomeric Insulation
 - 1. Acceptable Manufacturers
 - a. These specifications are based on products and data of Armacell and designate the type and quality of work intended under this section. Products of other manufacturers proposed as equivalent must be submitted for written approval by the specifying engineer ten days prior to the bid date. Supporting technical data, samples, published specifications and the like must be submitted for comparison. The contractor should warrant that proposed substitutions, if accepted, will provide performance equal to the materials specified herein. Insulation material shall be a flexible, closed-cell or conformable, elastomeric insulation in sheet form:

- 1) AP Armaflex, AP Armaflex SA, AP Coilflex or AP Spiralflex. These products meet the requirements as defined in ASTM C 534, Grade 1 Type II, "Specification for preformed elastomeric cellular thermal insulation in sheet and tubular form".
2. AP Armaflex and AP Armaflex SA insulation materials shall have a closed cell structure to prevent moisture from wicking and effectively retard heat gain to make it an efficient insulation. AP Coilflex has a conformable cell structure allowing it to be bent on a coil line brake for tight fit in the corners.
3. Insulation materials shall be manufactured without the use of CFC's, HFC's or HCFC's. It is also formaldehyde-free, low VOCs, fiber free, dust free and resists mold and mildew.
4. The insulation material shall conform to meet the requirements as defined in ASTM C 1534, Standard "Specification for Flexible Polymeric Foam Sheet Insulation Used as a Thermal and Sound Adsorbing Liner for Duct Systems".
5. Materials 2" thickness and below, shall have a flame spread index of less than 25 and a smoke developed index of less than 50 when tested in accordance with ASTM E 84, latest revision. In addition, the product, when tested, shall not melt or drip flaming particles, the flame shall not be progressive and all materials shall pass simulated end-use fire tests.
6. AP Armaflex and AP Armaflex SA materials shall have a maximum thermal conductivity of 0.25 Btu-in/h-ft² - °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
7. AP Armaflex and AP Armaflex SA materials shall have a maximum water vapor transmission of 0.05 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
8. AP Armaflex FS materials shall have a maximum thermal conductivity of 0.28 Btu-in/h-ft² - °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
9. AP Armaflex FS materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure A, latest revision.
10. Materials shall have a maximum water absorption rate of 0.2% (%by volume), when tested in accordance with ASTM C 209.
11. The material shall be manufactured under an independent third party supervision testing program covering the properties for fire performance, thermal conductivity and water vapor transmission.
12. Materials must be approved for air plenums.
13. Materials must meet NFPA 90A, NFPA 908 and UL 181 Class 1 specification.
14. Materials must meet ASTM C 411. Materials to perform up to 250°F.
15. Pertinent Duct Lining Specification Compliance.
16. ASTM C 1071 - Erosion Resistance.
17. ASTM G 21 - Fungi Resistance.
18. ASTM C 1338 - Fungi Resistance.
19. ASTM G 22 - Bacterial Resistance.
20. ASTM C 665 - Non Corrosiveness and no objectionable odors.
21. NRC rating 0.40 - Test Method ASTM C 423 with ASTM E 795 Type A Mounting. All product except AP Coilflex
22. NRC rating on the AP Coilflex is 0.60 - Test Method ASTM C 423 with ASTM E 795 Type A Mounting.
23. Dust free and fiber free. Non particulating.

2.2 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; FlameChek.
 - b. Johns Manville; Firetemp Wrap.
 - c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
 - d. Thermal Ceramics; FireMaster Duct Wrap.
 - e. 3M; Fire Barrier Wrap Products.
 - f. Unifrax Corporation; FyreWrap.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 - 2. 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).
 - 3. 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."
- C. ASJ Adhesive, and FSK Jacket Adhesive:
 - 1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60.

d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. 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."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers CP-38
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - c. Vimasco Corporation; 749.
2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.

5. Color: White.

2.5 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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. ASJ Flashing Sealants, and Vinyl Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
 - b. Vimasco Corporation; Elastafab 894.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.
2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide.

1. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

B. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

- a. Products: Subject to compliance with requirements available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
 - 2) GEMCO; Perforated Base.
 - 3) Midwest Fasteners, Inc.; Spindle.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, or Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
- a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GEMCO; Nylon Hangers.
 - 2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
- a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
 - 2) GEMCO; Peel & Press.
 - 3) Midwest Fasteners, Inc.; Self Stick.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.

- c. Spindle: Copper- or zinc-coated, low-carbon steel, Aluminum, or Stainless steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
- 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel, or 0.062-inch (1.6-mm) soft-annealed, galvanized steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) 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 (50 mm).
 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 (50 mm).

1. Comply with requirements in other sections for firestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Seal penetrations through fire-rated assemblies.

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) 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 (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) 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 (75 mm).

5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. AP Armaflex and AP Armaflex FS Sheet and Rolls

1. Armaflex Sheet Insulation shall be adhered directly to clean, oil-free surfaces with a full cover age of Armaflex 520, 520 Black or Low VOC Spray Adhesive. Apply 520, 520 Black and Spray Adhesive to both the Armaflex surface and sheet metal.
2. Ambient temperature for applications is between 40 degrees F and 100 degrees F.
3. The skin side (smooth side) shall be exposed to the air stream.
4. Butt-edge seams shall be adhered using Armaflex 520, or 520 Black Adhesive by the compression fit method to allow for expansion/contraction. Leave a 1/2" wide uncoated border at the butt edge seams on the duct surface and the insulation surface. Overlap the insulation 1/4" at the butt-edges and compress the edges into place. Apply Armaflex 520 or 520 Black. Allow 48 hours for full cure prior to operating system.
5. Length of duct should allow for reaching in to apply 100% pressure to all interior surfaces.
6. Refer to Armacell's Installation Booklet for additional installation information.

B. Self Adhering (SA) Armaflex Sheet and Rolls

1. SA Armaflex sheet shall be applied directly to a clean, dry, oil-free surface.
2. Ambient temperature for application must be between 40°F and 100°F.
3. The skin side (smooth side) shall be exposed to the air stream.
4. Install all sheet butt joints with a compression fit. Overlap the insulation 1/4" at the butt-edges and compress the edges into place. Leave 1/2" wide release liner border at the butt edge.
5. Refer to Armacell's Installation Booklet for additional installation information.

C. Air Velocities above 4,000 FPM (20.3 m/second): Metal nosing should be applied to every leading edge.

D. AP Coilflex should be applied using an automatic coil line and water based adhesive

E. AP Spiralflex should be applied to the inside of round duct according to the installation guide written specifically for the AP Spiralflex

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.7 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. Grease duct serving a Type I hood that penetrates a ceiling, wall, floor or any concealed spaces shall be enclosed from the point of penetration to the outlet terminal.
- C. Insulate duct access panels and doors to achieve same fire rating as duct.
- D. Install firestopping at penetrations through fire-rated assemblies.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

- A. Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.

2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return air in unconditioned space.
4. Indoor, exposed return air in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.10 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

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

1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.

B. Concealed, round and flat-oval, return-air (in indirectly conditioned, plenum spaces) duct insulation:

1. No insulation required.

C. Concealed, round and flat-oval, outdoor-air (unconditioned) duct insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

D. Concealed, round and flat-oval, exhaust-air duct insulation between the building exterior and the backdraft damper shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.

E. Concealed, rectangular, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.

F. Concealed, rectangular, return-air duct (return boots only), and all transfer ducts insulation shall be the following:

1. Mineral-Fiber Blanket: 1/2 inches acoustic duct liner

G. Concealed, rectangular, return-air (in unconditioned space) duct insulation shall be the following:

1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.

- H. Concealed, rectangular, outdoor-air (unconditioned) duct insulation shall be the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- I. Concealed, rectangular, exhaust-air duct insulation between the building exterior and the backdraft damper shall be the following:
 - 1. Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
- J. Exposed, round and flat-oval, supply-air duct in unconditioned space insulation shall be the following:
 - 1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
 - 2. Normally occupied areas: 1" double wall duct.
- K. Exposed, round and flat-oval, supply-air duct in conditioned space insulation shall be the following:
 - 1. None
- L. Exposed, round and flat-oval, return-air duct insulation:
 - 1. No insulation required
- M. Exposed, round and flat-oval, return-air (in unconditioned space) duct insulation:
 - 1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- N. Exposed, round and flat-oval, outdoor-air (unconditioned) duct insulation shall be the following:
 - 1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 - 2. Normally occupied areas: Flexible Elastomeric Lining: 3/4 inch.
- O. Exposed, round and flat-oval, exhaust-air duct insulation between the building exterior and the backdraft damper shall be one of the following:
 - 1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 - 2. Normally occupied areas: Flexible Elastomeric Lining: 3/4 inch.
- P. Exposed, rectangular, supply-air duct in unconditioned space insulation shall be one of the following:
 - 1. Back of house and not normally occupied areas storage rooms, etc.): Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
 - 2. Normally occupied areas: R-6 minimum, Flexible Elastomeric Lining: 1-1/2 inch.

- Q. Exposed, rectangular, supply-air duct in conditioned space insulation shall be one of the following:
1. None
- R. Exposed, rectangular, return-air duct insulation:
1. No insulation required.
- S. Exposed, rectangular, return-air (in unconditioned space) duct insulation:
1. Mineral-Fiber Blanket: R-6 minimum, 2 inches thick and 1.5-lb/cu. ft. nominal density.
- T. Exposed, rectangular, outdoor-air (unconditioned) duct insulation shall be the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Normally occupied areas: Flexible Elastomeric Liner: 3/4 inch.
- U. Exposed, rectangular, exhaust-air duct insulation between the building exterior and the backdraft damper shall be one of the following:
1. Back of house and not normally occupied areas: Mineral-Fiber Blanket: 1-1/2 inches thick and 0.75-lb/cu. ft. nominal density.
 2. Normally occupied areas: Flexible Elastomeric Liner: 3/4 inch.
- V. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket; thickness as required to achieve 2-hour fire rating. Grease duct serving a Type I hood that penetrates a ceiling, wall, floor or any concealed spaces shall be enclosed from the point of penetration to the outlet terminal.

END OF SECTION 230713

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SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Heating, hot-water pumps.
2. Expansion/compression tanks.
3. Air separators.

- B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 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.

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. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide.
- D. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
- E. 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. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Armacell LLC; AP Armaflex or AP Armaflex FS or a comparable product by one of the following:
 - a. Aeroflex USA, Inc.
 - b. K-Flex USA.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Armacell LLC; Armaflex 520 Adhesive or a comparable product by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. K-Flex USA.

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

1. 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).
2. 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."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
4. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
3. Solids Content: 60 percent by volume and 66 percent by weight.
4. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Permanently flexible, elastomeric sealant.
3. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
4. Color: White or gray.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants 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. 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 (Minus 40 to plus 121 deg C).
4. Color: Aluminum.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants 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."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Sealants 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."

2.6 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Sheet and roll stock ready for shop or field sizing.
 2. Finish and thickness are indicated in field-applied jacket schedules.
 3. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 4. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 5. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.

- g. Valve covers.
- h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 11.5 mils (0.29 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Width: 3 inches (75 mm).
 - 2. Thickness: 6.5 mils (0.16 mm).
 - 3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 6 mils (0.15 mm).
 - 3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches (50 mm).
 - 2. Thickness: 3.7 mils (0.093 mm).
 - 3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
- E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
 - 1. Width: 3 inches (75 mm).
 - 2. Film Thickness: 4 mils (0.10 mm).
 - 3. Adhesive Thickness: 1.5 mils (0.04 mm).
 - 4. Elongation at Break: 145 percent.

5. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.9 SECUREMENTS

- A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
- B. Insulation Pins and Hangers:
1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
 - b. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
 - b. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- D. Wire: 0.080-inch (2.0-mm) nickel-copper alloy.

2.10 CORNER ANGLES

- A. PVC Corner Angles: 30 mils (0.8 mm) thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch (1.0 mm) thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.

- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.3 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.
4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
 - d. Do not overcompress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

B. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from aluminum, at least 0.040 inch (1.0 mm) thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

C. Flexible Elastomeric Insulation Installation for Pumps:

1. Follow manufacturer's written instructions.

3.4 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections: Inspect field-insulated equipment, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to two location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.

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

3.6 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.

3.7 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.
- C. Heating-hot-water pump insulation shall be the following:
 - 1. Mineral-Fiber Board: 2 inches nominal density.
- D. Heating-hot-water expansion/compression tank insulation shall be the following:
 - 1. Mineral-Fiber Pipe and Tank: 1 inch thick.
- E. Heating-hot-water air-separator insulation shall be the following:
 - 1. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.8 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Equipment, Concealed:
 - 1. None.
- D. Equipment, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches:
 - 1. Aluminum, Stucco Embossed: 0.020 inch thick.
- E. Equipment, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:
 - 1. Aluminum, Stucco Embossed: 0.032 inch thick.

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13-23128-00
9 FEBRUARY 2024
BID SET

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors
 - 2. Heating hot-water piping.
 - 3. Refrigerant piping.
- B. Related Sections:
 - 1. Section 230713 "Duct Insulation."
 - 2. Section 230716 "HVAC Equipment Insulation."

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- B. Products located in return air plenums shall be noncombustible with a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested in accordance with ASTM E 84.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
- G. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000-Degree Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 - 2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Aeroflex USA, Inc.; Aero seal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. 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."

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

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.

2. 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).

3. 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."

- 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.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
 - d. Mon-Eco Industries, Inc.; 22-25.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. 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."

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. 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."

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
 - b. Eagle Bridges - Marathon Industries; 550.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
 - d. Mon-Eco Industries, Inc.; 55-50.
 - e. Vimasco Corporation; WC-1/WC-5.
2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- D. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
 2. Sheet and roll stock ready for shop or field sizing.
 3. Finish and thickness are indicated in field-applied jacket schedules.
 4. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
 5. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 6. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.

- b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Polyguard Products, Inc.; Alumaguard 60.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 - 2. Width: 3 inches (75 mm).
 - 3. Thickness: 11.5 mils (0.29 mm).
 - 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
 3. Thickness: 6.5 mils (0.16 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.
 2. Width: 2 inches (50 mm).
 3. Thickness: 3.7 mils (0.093 mm).
 4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.9 SECUREMENTS

- A. Aluminum Bands: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.
- C. Wire: 0.080-inch (2.0-mm) nickel-copper alloy, 0.062-inch (1.6-mm) soft-annealed, stainless steel, or 0.062-inch (1.6-mm) soft-annealed, galvanized steel.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. If applicable, coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.

- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.

6. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 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 other sections for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies.

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate 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 thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 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 (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as 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.

3.6 INSTALLATION OF MINERAL-FIBER PREFORMED PIPE 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 (150 mm) o.c.
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.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), 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.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
 - 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Where metal jackets are indicated, install with 2-inch (50-mm) 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 (300 mm) o.c. and at end joints.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of fittings and three locations of specialties such as valves, etc.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable insulation and jacket materials are identified above. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

3.10 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate Drains:
 - 1. All Pipe Sizes: Insulation shall be one of the following:

- a. Flexible Elastomeric: 1/2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
 - B. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
 - 1. NPS 1-1/4" and Smaller: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1-1/2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 1-1/2 inch thick.
 - 2. NPS 1-1/2" and Larger: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 2 inch thick.
 - b. Mineral-Fiber, Preformed Pipe, Type I: 2 inch thick.
 - C. Heat Pump Systems Systems, All Piping:
 - 1. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2. Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
 - D. Non-Heat Pump, Cooling Only Systems, Cold Refrigerant Suction Piping Only:
 - 1. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - 2. Flexible Elastomeric: 1 inch (25 mm) thick.
 - 3. Glass-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
- 3.11 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
 - A. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:
 - 1. Cellular Glass: 3 inches (75 mm) thick.
 - 2. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - B. Heat Pump Systems, All Piping:
 - 1. Cellular Glass: 2 inches (50 mm) thick.
 - 2. Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - C. Non-Heat Pump, Cooling Only Systems, Cold Refrigerant Suction Piping Only:
 - 1. Cellular Glass: 2 inches (50 mm) thick.
 - 2. Flexible Elastomeric: 2 inches (50 mm) thick.
 - 3. Glass-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
 - D. INDOOR, FIELD-APPLIED JACKET SCHEDULE
 - E. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

F. Piping, Concealed:

1. None.

G. All Piping, Exposed, 10'-0" above finished floor and lower:

1. PVC: 30 mils (0.8 mm) thick.

3.12 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Piping, Concealed:

1. None.

C. Piping, Exposed, shall be one of the following:

1. Aluminum, Smooth 0.024 inch thick.
2. Self-Adhesive Outdoor Jacket

3.13 END OF SECTION 230719

SECTION 230900 - DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. The control system shall be Automated Logic by Control Services Company (Stanley Chandler, Justin Smith)
- B. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- C. The control system shall consist of a high-speed, peer-to-peer network of DDC controllers.
- D. Except as indicated, all work related to the Server shall be provided by the Section 250950 "Integration of Building Automation Systems."
- E. System software shall be based on a server/thin-client architecture, designed around the open standards of web technology. The control system server shall be accessed using a web browser over the control system network, the Owner's local area network, and remotely over the Internet through the Owner's LAN.
- F. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).
- G. The intent of the thin-client architecture is to provide operators complete access to the control system via a web browser. No special software other than a web browser shall be required to access graphics, point displays, and trends, configure trends, configure points and controllers, or to edit programming.
- H. Performance Monitoring: The BAS will provide the specified performance monitoring functionality, including required monitoring points and performance metrics, improved through system accuracy, data acquisition and data management capabilities. Required graphical and data displays shall be provided by the Section 250950 Integration of Building Automation Systems contractor.
- I. Event Response: The BAS will provide the specified operational changes based on event response from the energy service provider.
- J. All labor, material, equipment and software not specifically referred to herein or on the plans, that is required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.

1.3 SYSTEM DESCRIPTION

- A. The Building Automation System (BAS) shall be comprised of Network Area Controller or Controllers (NAC) and a dedicated communication network within each facility. The NAC shall connect to the dedicated BAS communication network and include network switches as necessary for a single point of connection to the owner's local or wide area network, depending on the owner's configuration. Access to the system, either locally in each building, or remotely from a central site or sites, shall be accomplished through standard Web browsers, via the Internet and/or local area network. Each NAC shall communicate to BACnet (IBC) controllers and other open and legacy protocol systems/devices as required by the construction when existing controllers are to remain or specialty equipment is part of the project.
- B. The controls system shall conform to the following guidelines for communication protocols.
 - 1. BACnet shall be used for all BAS provided controllers.
 - a. The manufacturer of the hardware and software components as well as its subsidiaries must be a member in good standing of the BACnet International and all controllers used shall be BACnet Listed with documentation on the BACnet website (<https://www.bacnetinternational.net/btl/search.php>)
 - b. The use of BACnet Communications protocol alone shall NOT warrant an "Open System Design." Manufacturers must adhere to all aspects of "BAS Open System Design and Qualifications" and "Acceptable System Manufacturers" sections to comply.
 - 2. Modbus shall only be acceptable for third party devices.
 - 3. LonTalk shall only be acceptable for sites with existing LonTalk controls architecture where the owner has explicitly stated that the LonTalk architecture must remain in place.
 - 4. Proprietary communications protocols shall NOT be acceptable.
- C. The Building Automation System (BAS) as provided in this Division shall be based on the Niagara Framework (or "Niagara"), a framework developed by Tridium. All aspects of the system shall be provided using open protocol and open automation infrastructure that integrates diverse systems and devices (regardless of manufacturer, communication standard or software) into a unified platform that can be easily managed in real time over the Internet using a standard Web browser. Systems not developed on the Niagara Framework platform are unacceptable.
- D. Coordinate with the owner's IT staff to ensure that the BAS will perform in the owner's environment without disruption to any of the other activities taking place on that LAN.
- E. All points of user interface shall be on standard computing devices that do not require the purchase of any special software from the BAS manufacturer for use as a building operation terminal. The primary point of interface on these devices will be a standard Web Browser.

1.4 DIVISION OF WORK

- A. It shall be the work of this Section to be responsible for all controllers including Network Area Controller(s), field level controllers, control devices, control panels, cabling and raceways, controller programming, controller programming software, point mapping/binding to match

established naming standards controller input/output, and power wiring and controller network wiring.

1. 120v power: The temperature controls contractor is responsible for cost associated with providing 120v power required for all control equipment (panels, controllers, etc.) and coordination with the electrical contractor for providing power at such locations as determined by the controls contractor. The controls contractor is also responsible for cost associated with providing 120/24v transformers where required for controls and equipment. Coordinate with the mechanical and electrical contractors.
 2. Data Drops: The temperature controls contractor is responsible for cost associated with providing data drops required for all control equipment (panels, controllers, etc.) and coordination with other trades as required for providing drops at such locations as determined by the controls contractor.
- B. It shall be the work of Section 250950 "Integration of Building Automation Systems" for interfacing with Network Area Controller(s), graphical user interface software (GUI), development of all graphical screens, Web browser pages, setup of schedules, logs and alarms, historical and utility trending.

1.5 SYSTEM DESIGN RESPONSIBILITY

- A. All work shall comply with all local codes, laws, and governing bodies. If the drawings or specifications are in conflict with governing codes, submit a proposal with appropriate modifications to the project to meet code restrictions. If the drawings or specifications exceed governing code requirements, this specification and the associated drawings shall govern.
- B. Design and provide all conduit, cable hooks, and wiring linking all elements of system, including future capability.
- C. Design and provide all material for interfaces to existing pneumatic controls where applicable.
- D. Location of controllers to be approved by Owner or engineer prior to installation.
- E. 120 Volt Power: Provide 120 Volt power required for all control equipment (panels, controllers, etc.) and coordinate with other trades for providing power at locations necessary for a fully functional control system.
 1. Provide low voltage transformers, fusing, switches, low voltage wiring, conduit, and all other electrical components as required for controls and equipment.
 2. Provide utility power or emergency power where directed and/or indicated on drawings, to controllers.
- F. Data Drops: Provide data required for all control equipment (panels, controllers, etc.) and coordinate with other trades as required for providing data drops at locations necessary for a fully functional control system.
- G. No more than thirty-two (32) devices shall be daisy chained on any communication trunk.

1.6 DEFINITIONS

A. The following definitions may or not be used in this document:

1. AI: Analog Input
2. AO: Analog Output
3. ASCII: American Standard Code for Information Interchange
4. At no additional cost. The phrase "at no additional cost" shall mean at no additional cost to the Owner and at no additional cost to the Architect, Engineer or Owner's Representative.
5. BACnet: A data communication protocol for building automation and control networks. The rules governing this protocol are defined in ASHRAE/ANSI Standard 135.
6. BAS: Building Automation System
7. BI: Binary Input
8. BMP: The standard bit-mapped graphics format used in the Windows environment. By convention, graphics files in the BMP format end with a ".BMP" extension.
9. BO: Binary Output
10. Bridge: A device that connects two local-area networks (LANs), or two segments of the same LAN that use the same protocol, such as Ethernet or Token-Ring.
11. DDC: Direct Digital Control. The digital algorithms and pre-defined arrangements included in the control system software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.
12. DDE: Dynamic Data Exchange
13. Ethernet: Local area network (LAN)
14. Firewall: A system designed to prevent unauthorized access to or from a private network.
15. Furnish: The term "Furnish" and its derivatives when used in this Division shall mean supply at the Contractor's cost to the designated third party trade contractor for installation. The Contractor shall connect furnished items to the system, calibrate, test, verify, warrant and document.
16. GUI: Graphical User Interface
17. Hub: A common connection point for devices in a network.
18. HTML: HyperText Markup Language.
19. HTTP: HyperText Transfer Protocol,
20. IBC: Interoperable BACnet Controller
21. IDC: Interoperable Digital Controller
22. ILC: Interoperable LonWorks Controller
23. Install: The term "Install" and its derivatives when used in this Division shall mean receive at the jobsite and mount.
24. Integration: The ability to link disparate control system devices into a cohesive Building Automation System.
25. Interoperability: The ability of disparate control system devices to work together toward a common objective through the exchange of information.
26. IP: Internet Protocol.
27. JACE: Java Application Control Engine
28. LAN Local Area Network
29. LCU: Local Control Unit

30. LonMark: A set of protocol rules and practices that has been developed and approved by a group of manufacturers that use the “Neuron” processor chip developed by the Echelon Corporation.
31. LonTalk: A local area network (LAN) technology created by the Echelon Corporation.
32. LonWorks®: An encompassing term that includes the LonTalk communications protocol, devices that use the LonTalk protocol (LonMark devices) and the network on which the devices reside.
33. MS/TP: Master slave/token passing.
34. NAC: Network Area Controller
35. NICS: NiagaraAX Compatibility Statement
36. ODBC: Open DataBase Connectivity.
37. OLE: Object Linking and Embedding.
38. OOT: Object Oriented Technology
39. OPC: Object Linking and Embedding (OLE) for Process Control.
40. PC: Personal computer.
41. PICS: Product Interoperability Compliance Statement
42. PID: Proportional plus integral plus derivative.
43. PMI Power Measurement Interface
44. Point: A point may be logical or physical. Logical points are values calculated by system such as totals, counts, derived corrections i.e. as result of and/or statements in CDL's. Physical points are inputs or outputs, which have hardware, wired to controllers which are measuring or providing status conditions of contacts or relays providing interaction with related equipment (stop, start) or valve or damper actuators.
45. POT: Portable Operator's Terminal
46. Protocol: An agreed-upon format for transmitting data between two devices.
47. Provide: The term “Provide” and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, verify, warrant, document and supply the associated required services ready for operation.
48. RTD: Resistance temperature detector.
49. SQL: Structured Query Language.
50. TCP: Transmission Control Protocol.
51. TCP/IP: Transmission Control Protocol/Internet Protocol.
52. TCU: Terminal Control Unit
53. Thick Client: In a “thick” client/server architecture, the client does the majority of the processing.
54. Thin Client: In a “thin” client/server architecture, most of the processing is handled by the server and all the browser has to do is process the display.
55. UPS: Uninterruptible Power Supply.
56. Virtual Point: A point of information that is generated as a software value rather than the value being generated by an actual hardware device.
57. WAN: Wide Area Network
58. WBI: Web Browser Interface
59. XML: Extensible Markup Language.

1.7 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:

1. Object Command: Devices shall react to command of a binary object within 2 seconds. Devices shall begin reacting to command of an analog object within 2 seconds.
2. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
3. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
4. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control. Select execution times consistent with the mechanical process under control.
5. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per second. Select execution times consistent with the mechanical process under control.
6. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 seconds of other workstations.
7. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances as listed below:

**Sensors, Meters, Calculated Values, and Required Accuracies
When Not Specified Elsewhere**

#	Object Description & Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval, min	Trend Interval, min	Accuracy Req'd for Control
S1	Ambient Dry-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	-20°F to 120°F	±1.0°F	±0.02°F	1	10	±2°F
S2	Ambient Wet-Bulb Temperature	AI	Locate in weather station or ventilated enclosure in fully shaded location away from thermal mass bodies	-20°F to 120°F	±0.5°F	±0.02°F	1	10	±3°F
S3	Dew Point	AI	Chilled mirror, infrared, capacitive	10°F to 100°F	±3°F	±0.1°F			±3°F
S4	Building Main Natural Gas Meter	BI	Positive displacement pressure compensated; continuous output		±1% of reading, > 10:1 turndown	0.1 scfm	1	10	—
S5	Natural Gas Flow Rate (e.g., boiler)	AI/BI (pulse)	Positive displacement pressure compensated; continuous output		±2% of reading, > 10:1 turndown	0.1 scfm	1	10	—
S6	Building Main Meter Power	BI	True RMS to 50 th harmonic		±1.0% of reading	0.1 kW	1	1	0.1 kW

#	Object Description & Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval, min	Trend Interval, min	Accuracy Req'd for Control
S7	Electric Power Sub-meter (e.g., Lighting	AI/BI (pulse)	True RMS to 50th harmonic		±1.0% of reading	0.001kW			—
S8	Zone (Space) Temperature	AI	10000 ohm thermistor or 1000 ohm RTD	30°F to 100°F	±0.5°F	±0.1°F	1	1	±1°F
S9	Carbon Dioxide	AI	Nondispersive infrared sensor technology	0 to 2000 ppm	±2% of reading, ±30 ppm	50 ppm	1	1	40 ppm
S10	Carbon Monoxide	AI	Electrochemical sensor	0 to 100 ppm	±5 ppm	50 ppm	1	1	50 ppm
S11	Air Pressure (Ducts)	AI	Variable capacitance	0 to 8 in. w.g.	±0.1 in. w.g.	±0.5 in. w.g.	1	1	0.1 in. w.g.
S12	Air Pressure (Space)	AI	Variable capacitance	−0.1 to 0.1 in. w.g.	0.01 in. w.g.	±0.01 in. w.g.	1	1	0.005in. w.g.
S13	Water Pressure	AI		0 to 150 psi	±2% of reading	1 psi	1	1	0.5 psi
S14	Water Temperature	AI		32°F to 225°F	±1°F	±0.1°F	1	1	±3°F
S15	Delta-T	AI	10000 ohm thermistor or 1000 ohm RTD matched pair		±0.25°F	±0.5°F	1	1	±0.25°F
S16	Relative Humidity	AI		0% to 100%	±5% RH	5%	1	1	±5% RH
S17	Heating Hot-Water Flow	AI			±2% of reading	5 gpm	1	1	
S18	Ducted Air Temperature	AI	10000 ohm thermistor or 1000 ohm RTD	45°F to 140°F	±1°F	1°F	1	1	±1°F
S19	Electrical (A, V, W, Power Factor)	AI/BI (pulse)	True RMS, three-phase, stand-alone analog or pulse output or networked meter; use maximum resolution if pulse output		±1% of full scale	0.1	1	1	—

#	Object Description & Location if Applicable	Sensor or Value Type	Sensor Type or Calculation Method	Expected Range	Required End-to-End Accuracy	Display Resolution	Refresh Interval, min	Trend Interval, min	Accuracy Req'd for Control
S20	Chiller Power	AI	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading	0.01 kW	1	1	—
S21	Primary Chilled Water Pump Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—
S22	Condenser Water Pump Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—
S23	Cooling Tower Fan Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—
S24	Secondary Chilled-Water Pump Power	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.01 kW	1	1	—

S25	Chilled-Water Plant Chilled-Water Temperatures	AI	10000 ohm thermistor or 1000 ohm RTD (matched with S26)		±0.1°F	±0.01°F	1	1	±1°F
S26	Chilled- Water Flow Rate	AI	Hot tapped insertion flow-meter		±2% of reading, > 20:1 turn-down	0.1 gpm	1	1	—
S27	Air-Handling Unit Fan Airflow Rate	AI	Vortex shedding sensor on fan inlet		±5% of reading down to 150 ft/min	0.1 cfm	1	1	±5% of reading down to 150 ft/min
S28	Airflow (Measuring Stations)	AI	Electronic or differential pressure		±5% of reading	100 cfm	1	1	±5% of reading
S29	Airflow (Measuring Stations)	AI	Thermal Dispersion		±5% of reading	1 cfm	1	1	±5% of reading
S30	Airflow (Terminal)	AI	Electronic or differential pressure		±10% of reading	100 cfm	1	1	±10% of reading
S31	Airflow (Pressurized Spaces)	AI	Electronic or differential pressure		±3% of reading	50 cfm	1	1	±3% of reading
S32	Air Handling Unit Fan Power (or use of integrated VFD)	AI/BI (pulse)	True RMS, three-phase, integrated equipment, stand-alone analog or pulse output or networked power meter; use maximum resolution if pulse output		±1.5% of reading; ±3.0% of reading if from VFD	0.1 kW	1	1	—
S33	Air Handling Unit Supply Air Temperature	AI		45°F to 120°F	±0.35°F	0.02°F	1	10	±1°F
S34	Air Handling Unit Mixed Air Temperature	AI	Locate in air handler's mixed air section; to minimize effects of stratification use averaging sensor if possible	40°F to 100°F	±0.35°F	0.02°F	1	10	±1°F
S35	Air Handling Unit Return Air Temperature	AI	Locate upstream of air handler's return air damper	60°F to 90°F	±0.35°F	0.02°F	1	10	±1°F

S36	Air Handling Unit Demanded Damper Position	AI	Virtual point that commands the damper position	0% to 100%	N/A	0.1%	1	10	—
S37	Hot Water Flow Rate	AI	Hot tapped insertion flow-meter		±2% of reading, > 20:1 turn-down	0.1 gpm	1	1	—
M1	Whole-Building Peak Power	AI/BI (pulse)	Maximum of measured value S6 over a given time interval		±1%	0.1 kW	1	10	1kW
M2	Whole-Building Area Normalized Electric Energy-Use Intensity	Calculated	Measured value S6 integrated over a given interval divided by a constant #C1 = building area, ft ²		±1%	0.1 kWh/ft ²	1	10	—
M3	Whole-Building Natural Gas Heat Rate	Calculated	Measured value S4 divided by a constant #C2 = 0.01 therm/standard cubic feet		±1.5%	0.1 therms/min	1	10	—
M4	Whole-Building Area Normalized Gas Energy-Use Intensity	Calculated	Calculated value M3 integrated over a given interval divided by a constant #C1 = building area, ft ²		±1.5%	0.1 therms/ft ²	1	10	—
M5	Average Daily Outdoor Ambient Temperature	Calculated	Average of instantaneous measured values (S1)		±0.35°F	±0.02°F	1	10	—
M6	Chilled-Water Plant Chilled Water Supply Return Temperature Difference	Calculated	Calculated difference of two measured values (S25 – S26); sensors should be a matched pair		2% of reading or ±0.15°F	±0.01°F	1	1	±0.15°F
M7	Chilled-Water Plant Power	Calculated	Sum of measured values S20, S21, S22, S23, S24		±1.5%	0.1 kW	1	10	±1 kW
M8	Chilled-Water Loop Thermal Cooling Output	Calculated	Calculated value M6 multiplied by measured value S27 multiplied by a constant #C3 = 1.0 kW (500 min- tons/°F·gal)		±3%	0.3 kW (0.1 tons)	1	10	—

M9	Chilled-Water Plant Efficiency	Calculated	Calculated value M7 divided by calculated value M8		±4%	0.03 COP (0.01 kW/ton)	1	10	—
M10	Total Air Handling Unit Power	Calculated	Sum of calculated values S32x		±1.5%	0.1 kW	1	10	—
M11	Total Air-Handling Unit Flow	Calculated	Sum of measured values S28x		±5%	0.05 L/s (0.1 cfm)	1	10	—
M12	Total Air-Handling Unit Specific Power	Calculated	Calculated value M10 divided by value M11		±6%	0.0002kW/(L/s)(0.0001 kW/cfm)1	1	10	—
M13	Air Handling Unit Percentage Outdoor Air	Calculated	Instantaneous difference of two measured values (S35 – S36)/(S1 – S36); this can be used as an estimate of outdoor air percentage of total airflow, provided that the air temperature difference between the outdoor air and the return air is at least 5°C (11°F)	0% to 100%	N/A	0.001	1	1	—

1.8 SUBMITTALS

A. Qualification Data: Installer must submit documentation showing:

1. A minimum of 5 years of experience in direct digital control building automation.

B. Product Data: Include manufacturer's technical literature for each control device. Indicate exact model, options, dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated. Provide a concordance schedule for controllers indicating method of compliance with each item of this specification.

C. 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. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for controllers, control units, interface equipment, transducers/transmitters, meters, sensors, actuators, valves, relays/switches, and control panels,
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.

- c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Details of control panel faces, including controls, instruments, and labeling.
4. Written description of sequence of operation.
5. Schedule of controllers, including which panel controller is installed in, panel location, controller name, network number and instance number.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including size and flow characteristics.
8. Control System Software: Include technical data for operating system software and other third-party applications.
9. In all cases, control identification shall match equipment tags nomenclature as indicated on the Contract Documents.
10. Controlled Systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram.
 - d. Points list.
- D. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with either ASHRAE 135.
- E. Samples for Initial Selection: For each color required, of each type of thermostat or sensor cover with factory-applied color finishes.
- F. Software and Firmware Operational Documentation: Include the following:
 1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application.
 5. Software license required by and installed for DDC workstations and control systems.
- G. Field quality-control test reports, including point-to-point checkout documentation. Report shall be submitted in electronic format in Microsoft Excel™ and PDF. Report shall be submitted within two weeks of final check-out and prior to indicating readiness for commissioning functional testing.
- H. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Maintenance instructions and lists of spare parts for each type of control device.

2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 4. Calibration records and list of set points.
- I. Submit the Niagara Compatibility Statement (NICS) via a letter from the manufacturer. The NICS shall have no connectivity restrictions and all aspects of the Niagara Framework will be provided to maintain an Open System Design. The System as provided shall confirm with the following NiCS properties (Station Compatibility In, Station Compatibility Out, Tool Compatibility In, AND Tool Compatibility Out shall each have a value of "All").
1. Upon purchase of Network Area Controller, submit license file for review to confirm proper product is purchased.
- J. Upon completion of the work, provide a complete set of 'as-built' drawings in PDF format and application software on a backup drive or data stick.
1. As-built drawings shall incorporate updated written sequences to reflect final system operations.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project. Upon request, Installer shall present certification of completed training including hours of instruction and course outlines.
- B. Installing Office: The installing office shall have a minimum of five years of experience and shall provide documentation in the submittal package verifying the company's experience.
- 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. ASHRAE/ANSI 135-2001: Data Communication Protocol for Building Automation and Control systems (BACnet)

1.10 SOFTWARE LICENSE AGREEMENT

- A. The Owner shall sign a copy of the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
- B. It is the owners express goal to implement an open system that will allow products from various suppliers to be integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner

shall receive ownership of all job specific configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, BAS Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required IDs and passwords for access to any component or software program shall be provided to the owner. The owner shall determine which organizations to be named in the SI organization ID ("orgid") of all software licenses. Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier, by Tridium Inc.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.12 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with existing Fire Detection and Alarm systems to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate supply of electrical branch circuits for control units and operator workstation.
- D. All wall mounted thermostats, temperature sensors, and combination thermostats located in occupied spaces shall be provided by one manufacturer and have same visual appearance throughout the project.

1.13 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. Replacement Materials: One replacement diaphragm or relay mechanism for each unique valve actuator, controller, thermostat, positioning relay.
 - 2. Maintenance Materials: One thermostat adjusting key(s).

1.14 WARRANTY

- A. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted,

repaired, or replaced at no additional cost or reduction in service to Owner. Respond during normal business hours within 24 hours of Owner's warranty service request.

- B. Work shall have a single warranty date, even if Owner receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
- C. If Architect/Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Architect/Engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
- D. Upon notice by the Owner, any defects in the work provided under this section within the warranty period due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced at no expense to the Owner
- E. The Owner shall grant reasonable access to the contractor during the warranty period. The owner shall allow the contractor to access the BAS from a remote location via the Internet, for the purpose of diagnostics and troubleshooting during the warranty period.
- F. Provide updates to operator workstation software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.
 - 1. Exception: Contractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Architect/Engineer's acceptance.
- G. Special warranty on instrumentation:
 - 1. All instrumentation shall be covered by manufacturer's transferable one-year "No Fault" warranty. If manufacturer warranty is not available, the BAS installer shall provide the same.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide a control system by the following:
 - 1. Automated Logic by Control Services Company. No substitutions.

2.2 CONTROL SYSTEM

- A. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems.

2.3 NETWORK AREA CONTROLLER (NAC)

- A. Provide Network Area Controllers (NAC) as required to handle the Points List, Operating Sequences and Control Diagrams as indicated on the Drawings.
- B. The Network Area Controller (NAC) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. It shall be capable of executing application control programs to provide:
1. Calendar functions
 2. Scheduling
 3. Trending
 4. Alarm monitoring and routing
 5. Time synchronization
 6. Graphics screens
- C. The Network Area Controller (NAC) shall have a Niagara Compatibility Statement (NICS) as listed below:

Property	Value
Station Compatibility In	All
Station Compatibility Out	All
Tool Compatibility In	All
Tool Compatibility Out	All

- D. The Network Area Controller must provide the following hardware features as a minimum:
1. Supports standard Niagara objects and feature set components
 2. Supports Serial RS-232, RS-485 communication protocols with optional drivers
 3. Supports LonWorks, BACnet MS/TP, BACnet IP, Modbus, Sedona Framework with optional wireless option card, and Remote I/O modules
 4. Power - 15 volts DC @ 20 W from optional universal input Din-rail mounted supply
 5. Rechargeable internal NIMH battery backup, for short term power fail events. Built-in recharging and monitoring support for an external 12V sealed lead-acid backup battery, to allow system database save after power failure, plus maintenance of Real-time clock for up to one year.
 6. Built-in contact inputs are also available for UPS monitoring
 7. Multiple Mounting Options: DIN rail mounting or panel mounting using tabs on unit base
 8. Hardware Platform: 652 MHz 440Epx Power PC processor

9. Base unit – 1 GB DDR-2 333 MHz RAM, 512 MB NAND flash memory on board for database storage, trend storage and system software
 10. Operating System: QNX OS with IBM J9 Virtual Machine version (AX-3.5) or Oracle Hotspot Java 5 VM (AX 3.6 or higher)
 11. Two 1 Gigabit Ethernet ports
 12. One RS-232 and one isolated RS-485 ports
 13. Two NAC communication slots for optional NAC communication interface card use
 14. Compatible with Niagara Release 3.8 and Niagara Release 4.0. NAC configuration version shall be coordinated with Systems Integrator for each project.
 15. Power Input: 15 VDC at 20 Watts max. Uses NPB-WPM-US/U wall plug-in module or NPB-PWR-UN-H/U universal power supply
 16. Environment:
 - a. Operating Temperature Range: 32 to 122 °F
 - b. Relative Temperature Range: 10% to 90% RH at 77°F, non-condensing
 - c. Storage Temperature Range: 32 to 140 °F
 - d. Storage Relative Temperature Range: 5% to 94% RH, non-condensing
 17. Provide embedded work bench at each NAC Controller.
 18. Provide and configure NHaystack Add-in at each NAC Controller.
- E. The NAC shall support standard Web browser access via the Intranet/Internet.
- F. Event Alarm Notification and actions
1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network, remote connection, or wide-area network.
 3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
 - a. To alarm
 - b. Return to normal
 - c. To fault
 4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
 5. Provide timed (schedule) routing of alarms by class, object, group, or node.
 6. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.
- G. Control equipment and network failures shall be treated as alarms and annunciated.
- H. The following shall be recorded by the NAC for each alarm (at a minimum):
1. Time and date
 2. Location (building, floor, zone, office number, etc.)
 3. Equipment (air handler #, accessway, etc.)

4. Acknowledge time, date, and user who issued acknowledgement.
 5. Number of occurrences since last acknowledgement.
-
- I. Alarm actions may be initiated by user defined programmable objects created for that purpose.
 - J. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
 - K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
 - L. Provide a “query” feature to allow review of specific alarms by user defined parameters.
 - M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
 - N. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

2.4 FIELD LEVEL CONTROLLERS

A. BACnet Controllers:

1. Programmable Plant Controller with open license, for use in HVAC equipment:
 - a. Features:
 - 1) Niagara 4 compatible.
 - 2) Provide expansion I/O modules as required by each application
 - 3) Pre-licensed with BACnet, Lon and Modbus drivers
 - 4) Individually Licensed Controllers
 - 5) BACnet MS/TP or BACnet IP network communication.
 - 6) EIA-485 communications network, capable of baud rates between 9.6 and 115.2 kbits/s.
 - 7) Capable of stand-alone operation and BACnet MS/TP network communications.
 - 8) Sensor/Actuator bus for use with sensor/actuator bus-enabled sensors.
 - 9) Field configurable and programmable for control, input, and output functions using the NIAGARA FRAMEWORK software.
 - 10) Function Block engine, which allows the application designer to program the controller to perform a wide variety of HVAC applications.
 - 11) Built-in Zone Control functions include a remote wall module interface and a scheduler.
 - 12) Wiring connections to removable terminal blocks to simplify controller installation and replacement.
 - 13) Controller housing to be UL plenum rated.
 - 14) Listed under UL916 (Standard for Open Energy Management Equipment).
 - 15) Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
 - 16) Rated Voltage: 20-30 Vac; 50/60 Hz
 - 17) Power Consumption: 100 VA for controller and all connected loads

- 18) Controller only Load: 5 VA maximum
 - 19) External Sensors Power Output: 20 Vdc $\pm 10\%$ @ 75 mA maximum
 - 20) Operating & Storage Temperature Ambient Rating: Minimum 32° F and Maximum 122° F.
 - 21) Operating Relative Humidity Range: 10% to 90% non-condensing.
2. Programmable Controller, or use in convection units, radiant panels, unit heaters, unit ventilators, fan coil units, heat pumps Applications
 - a. Features:
 - 1) Niagara 4 compatible.
 - 2) Individually Licensed Controllers
 - 3) BACnet MS/TP or BACnet IP network communication.
 - 4) EIA-485 communications network, capable of baud rates between 9.6 and 115.2 kbits/s.
 - 5) Capable of stand-alone operation and BACnet MS/TP network communications.
 - 6) Sensor/Actuator bus for use with sensor/actuator bus-enabled sensors.
 - 7) Field configurable and programmable for control, input, and output functions using the NIAGARA FRAMEWORK software.
 - 8) Function Block engine, which allows the application designer to program the controller to perform a wide variety of HVAC applications.
 - 9) Built-in Zone Control functions include a remote wall module interface and a scheduler.
 - 10) Wiring connections to removable terminal blocks to simplify controller installation and replacement.
 - 11) Controller housing to be UL plenum rated.
 - 12) Listed under UL916 (Standard for Open Energy Management Equipment).
 - 13) Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
 - 14) Rated Voltage: 20-30 Vac; 50/60 Hz
 - 15) Power Consumption: 100 VA for controller and all connected loads
 - 16) Controller only Load: 5 VA maximum
 - 17) External Sensors Power Output: 20 Vdc $\pm 10\%$ @ 75 mA maximum
 - 18) Operating & Storage Temperature Ambient Rating: Minimum 40° F and Maximum 150° F.
3. Controller Input/Output Expansion Modules
 - a. Features:
 - 1) Niagara 4 compatible.
 - 2) Used to expand field controller's IO count.
 - 3) Capable of multiple expansion module arrays with field controller.
 - 4) Capable of communicating over the RS-485 MS/TP communications network or the sensor bus.
 - 5) Installation can be done locally or remotely from field controller.
 - 6) Field configurable and programmable for control, input, and output functions using the Niagara Framework® software.
 - 7) LED on the front of the device to provide a visual indication of device.

- 8) 32 bit ATMEL ARM 7 microprocessor.
- 9) Flash Memory: 512 kilobytes. Able to retain flash memory settings for up to ten (10) years.
- 10) RAM: 128 kilobytes
- 11) The device housing is UL plenum rated.
- 12) Listed under UL916 (Standard for Open Energy Management Equipment).
- 13) Meets FCC Part 15, Subpart B, Class B (radiated emissions) requirements.
- 14) Rated Voltage: 20-30 Vac; 50/60 Hz.
- 15) Power Consumption: 100 VA for device and all connected loads, 14 VA maximum for device only.
- 16) Operating & Storage Temperature Ambient Rating: Minimum 32° F and Maximum 122° F.
- 17) Operating Relative Humidity Range: 10% to 90% non-condensing.

2.5 SYSTEM TOOLS

A. General

1. Provided and licensed to the owner at project completion

B. Supervisory Controller Toolset

1. Device embedded and/or separate PC toolset shall provide the following capabilities in a graphical environment using a standard Web browser:
 - a. Device and point management
 - b. Scheduling, alarming and trending setup
 - c. Creation and binding of graphics
 - d. Time management
 - e. User management
2. Toolset provides all additional engineering capabilities for the NAC including but not limited to:
 - a. Editable table based point listings.
 - b. Automatically generated graphics for standard applications.

C. Programmable Controller Toolset for Field Controllers

1. The Programmable Controller Tool shall be capable of programming all Programmable Field Controllers.
 - a. The Programmable Controller tool shall provide the capability to configure, simulate, and commission all Programmable Field Controllers.
 - b. The Programmable Controller tool shall allow the application logic to be run in Simulation Mode to verify its sequence of operation.
 - c. The Programmable Controller tool shall contain a library of standard applications to be used for configuration.

D. Wireless Commissioning Converter (if applicable to the project)

1. The converter shall provide a temporary wireless connection between the SA or FC Bus and a wireless enabled portable PC.
2. The converter shall support downloading and troubleshooting Programmable Controllers from the PC over the wireless connection.
3. The converter shall employ Bluetooth Wireless Technology.
4. The converter shall be powered through a connection to either the Sensor-Actuator (SA) or the Field Controller (FC) Bus.
5. The converter shall operate over a minimum of thirty (30) feet within a building.
6. The converter shall have LED indicators to provide information regarding the following conditions:
 - a. Power - On/Off
 - b. Fault – Fault/No Fault
 - c. SA/FC Bus – Bus Activity/ No Bus Activity
 - d. Blue – Bluetooth Communication Established/ Bluetooth Communication Not Established

2.6 ENCLOSURES

- A. All controllers and field interface panels shall be mounted in new NEMA 1 enclosures unless otherwise stated.
- B. For all input/output devices which require field interface devices, these devices where practical shall be mounted in a field interface panel. All other field interface devices shall be mounted at the point of field interface in a separate enclosure suitable for the location. Provide an enclosure which protects the devices from dust, moisture, and conceals integral wiring and moving parts.
- C. Field interface panels shall contain power supplies for sensors, interface relays and contractors, safety circuits, and I/P transducers.
- D. The field interface panel enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and lock. The enclosure shall be sized for twenty percent spare mounting space. Each side of the cabinet shall have knockouts for rigid, soft, or flexible tubing. To join individual cabinets, remove knockouts and fasten appropriate fittings and locknuts.
- E. The tubing and wiring within all enclosures shall be run in plastic track to minimize loose wiring. Wiring within controllers shall be wrapped and secured.
- F. All tubing shall be connected to enclosures through conduit. Use bulkhead fittings where appropriate.

2.7 RELAYS

- A. General-Purpose Relays:
 1. NRTL listed.
 2. Heavy-duty, electromechanical type; rated for at least 10 A at 250 V ac and 60 Hz.
 3. SPDT, DPDT, or three-pole double-throw, as required by control application.

4. Plug-in-style relay with 8-pin octal or multiblade plug for DPDT relays and 11-pin octal or multiblade plug for three-pole double-throw relays.
5. Construct contacts of silver, silver alloy, or gold.
6. Enclose relay in a clear transparent polycarbonate dust-tight cover.
7. Include LED indication.
8. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 20 ms or less.
 - d. Dropout Time: 20 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2.5 VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
9. Equip relays with coil transient suppression to limit transients to non-damaging levels.
10. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
11. Include relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

B. Latching Relays:

1. NRTL listed.
2. Continuous-duty type, rated for at least 10 A at 250 V ac and 60 Hz.
3. SPDT, DPDT, or three-pole double-throw, as required by control application.
4. Plug-in-style relay with either multi-pin or blade plug.
5. Construct contacts of silver, silver alloy, or gold.
6. Enclose relay in a clear transparent polycarbonate dust-tight cover.
7. Performance:
 - a. Mechanical Life: At least 10 million cycles.
 - b. Electrical Life: At least 100,000 cycles at rated load.
 - c. Pickup Time: 20 ms or less.
 - d. Dropout Time: 20 ms or less.
 - e. Pull-in Voltage: 85 percent of rated voltage.
 - f. Dropout Voltage: 50 percent of nominal rated voltage.
 - g. Power Consumption: 2.5 VA or less.
 - h. Ambient Operating Temperatures: Minus 40 to 115 deg F.
8. Equip relays with coil transient suppression to limit transients to non-damaging levels.
9. Plug each relay into industry-standard, 35 mm DIN rail socket. Plug all relays located in control panels into sockets that are mounted on a DIN rail.
10. Relay socket with screw terminals. Mold into socket the coincident screw terminal numbers.

2.8 POWER SUPPLIES AND LINE FILTERING

- A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
 - 1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - a. Unit shall operate between 32°F and 120°F. EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA approved.
 - 2. Power line filtering.
 - a. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component. Surge protection shall have the following at a minimum:
 - 1) Dielectric strength of 1000 volts minimum
 - 2) Response time of 10 nanoseconds or less
 - 3) Transverse mode noise attenuation of 65 dB or greater
 - 4) Common mode noise attenuation of 150 dB or better at 40 Hz to 100 Hz

2.9 REMOTE COMMUNICATIONS

- A. Coordinate and follow the owner's security requirements for remote access.
- B. Provide all functions at the field level that will allow remote communications via Owner's intranet and/or Internet to offsite locations.
- C. Operators shall be able to access, from an offsite location, all objects, object properties and programs residing in all Building Controllers, System Controllers and Application Specific Controllers on a system wide basis. Operators shall be able to utilize the same set of system graphics that are utilized in the LAN based operator interfaces to remotely operate the system.
- D. All Building Controllers connected to the network shall be capable of automatically transmitting alarm messages through the network. The alarm information shall be directed to one or more of the devices described above.
- E. The NAC shall be capable of transmitting alarms to a minimum of 20 different destination devices. Destination devices may be selected by; type of alarm, time schedule, holiday schedule, or other selectable program parameters.
- F. Access to the Building Automation System shall be provided by means of a web browser and shall require no special software to be installed on the user's computer.

2.10 CONTROL PANELS

- A. All controllers shall be mounted in new control panels in locations as designated. Where locations of panels have not been delineated on drawings contractor shall submit proposed panel locations for review by the Architect/Engineer. Do not proceed with panel installation without obtaining approved locations from Architect/Engineer.
- B. Existing panels shall not be reused without obtaining specific written authorization from the Architect/Engineer.
- C. All indoor control cabinets shall be fully enclosed steel construction with hinged door and key lock. A single key shall be common to all field panels and subpanels.
- D. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
- E. Provide on/off power switch with over-current protection for control power sources to each local panel.
- F. Panel naming as well as all Controllers mounted within panel shall follow Specification Section 250924 "Temperature Control Equipment Naming Conventions."

2.11 NETWORKED THERMOSTAT

- A. General:
 - 1. Shall be capable of controlling two- or four-pipe fan coils, cabinet unit heaters or other similar equipment.
 - 2. Shall communicate over the Field Controller Bus using BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
 - 3. Shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - 4. Shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
 - 5. A BACnet Protocol Implementation Conformance Statement shall be provided for the network thermostat.
 - 6. Shall be capable of remote read/write and parameter adjustment from the web based User Interface (UI) through the Supervisory Controller.
 - 7. Shall include an intuitive User Interface providing plain text messages.
 - 8. Multi-line, backlit display
 - 9. LED indicators for Fan, Heat, and Cool status
 - 10. User Interface Keys
 - a. Mode
 - b. Fan
 - c. Override
 - d. Degrees C/F
 - e. Up/Down

11. The display shall continuously scroll through the following parameters:
 - a. Room Temperature
 - b. System Mode
 - c. Schedule Status – Occupied/Unoccupied/Override
 - d. Applicable Alarms
12. Shall provide the flexibility to support any one of the following inputs:
 - a. Integral Indoor Air Temperature Sensor
 - b. Duct Mount Air Temperature Sensor
 - c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator
 - d. Two configurable binary inputs
13. Shall provide the flexibility to support any one of the following outputs:
 - a. Three Speed Fan Control
 - b. Two On/Off
 - c. Two Floating
 - d. Two Proportional (0 to 10V)
14. Shall provide a minimum of six (6) levels of keypad lockout.
15. Shall provide the flexibility to adjust the following parameters:
 - a. Adjustable Temporary Occupancy from 0 to 24 hours
 - b. Adjustable heating/cooling deadband from 2° F to 5° F
 - c. Adjustable heating/cooling cycles per hour from 4 to 8
16. Shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

2.12 CO2 SENSOR

A. General:

1. Snap-on high impact ABS plastic faceplate.
2. Wall mounted microprocessor based non-dispersive infrared technology (NDIR) absorption sensing method
3. Input Power 20 to 30VDC/24VAC; 100mA max.
4. Analog Output 4-20mA, (clipped & capped)/0-5VDC/0-10VDC (selectable)
5. Operating Temperature Range 0° to 50°C (32° to 122°F)
6. Accuracy ± 30 ppm $\pm 2\%$ of measured value
7. Repeatability ± 20 ppm $\pm 1\%$ of measured value
8. Response Time <60 seconds for 90% step change
9. Measurement Range 0-2000/5000 ppm (programmable)
10. Sensor shall have no maintenance or periodic sensor replacement required. The sensor shall have a 7-year calibration interval, utilizing the Automatic Calibration Logic Program.

2.13 COMBINATION SENSORS

A. General:

1. Supply Voltage:18-30 VAC @ 0.7 VA, 50/60 Hz or 18-42 VDC @ 29 mA
2. Signal Output:0-5V, 0-10V, or 4-20 mA (500 ohms) selectable for CO2, humidity, or temperature (simultaneous current or voltage output for CO2)
3. Relay Type:SPDT, 0.5 A @ 125 VAC, 1 A @ 24 VDC
4. Display:Scrolling LCD
5. Response Time:5 seconds

B. Temperature Sensor:

1. Operating Temperature Range 50° to 95°F.
1. Accuracy: 1 percent full range with linear output
2. Temperature sensor's drift shall not exceed 1% of full scale per year.
3. Measurement Range: 32° to 122°F.

C. Humidity Sensor:

1. Operating Temperature Range 50° to 95°F.
2. Accuracy: 2 percent full range with linear output
3. Humidity sensor's drift shall not exceed 1% of full scale per year.
4. Measurement Range: 20 to 80 percent relative humidity.

D. Carbon Dioxide Sensor:

1. Operating Temperature Range 50° to 95°F.
2. Accuracy ± 30 ppm $\pm 3\%$ of measured value
3. Repeatability ± 20 ppm $\pm 1\%$ of measured value
4. Response Time <60 seconds for 90% step change
5. Measurement Range 0-2000.
6. Sensor shall have no maintenance or periodic sensor replacement required. The sensor shall have a 7-year calibration interval, utilizing the Automatic Calibration Logic Program.

E. Occupancy Sensor:

1. Onboard passive infrared (PIR) sensor that detects motion.
2. Minimum of 94 angular degrees sensing with a minimum 26 feet distance.

2.14 LOW TEMPERATURE SENSOR

- A. Electric low temperature warning thermostats shall be low point sensitive elements installed in serpentine manner to provide full coverage of the coil face. Averaging type are not acceptable.
- B. Thermostats shall be two-position, adjustable, automatic reset type.

- C. Low temperature thermostats shall be wired directly to the air handling unit equipment starter to shut down the unit without BAS action. Thermostats shall also be wired to BAS for annunciation.
- D. When installed on draw-thru units the elements shall be suspended on the mixed air side of the coil. Multiple bank coils shall have multiple low limit sensors installed and wired or piped in series.
- E. Each sensor shall cover no more than 20 sq. ft. of coil.

2.15 HUMIDITY SENSOR

- A. Manufacturers: Subject to compliance with requirements, available manufactures offering products that may be incorporated into the Work include:
 - 1. BEC Controls Corporation
 - 2. General Eastern Instruments
 - 3. MAMAC Systems, Inc
 - 4. Rotronic Instrument Corporation
 - 5. TCS/Basys Controls
 - 6. Vaisala
- B. General:
 - 1. Duct and room sensors shall have a sensing range of 20% to 80%.
 - 2. Duct sensors shall be provided with a sampling chamber.
 - 3. Outdoor air humidity sensors shall have a sensing range of 20% to 95% RH. They shall be suitable for ambient conditions of 40°F to 170°F.
 - 4. Humidity sensor's drift shall not exceed 1% of full scale per year.
 - 5. Humidity Sensors: Bulk polymer sensor element.
 - 6. Accuracy: 2 percent full range with linear output
 - 7. Room Sensor Range: 20 to 80 percent relative humidity.
 - 8. Room Sensor Cover Construction: Manufacturer's standard locking covers.
 - 9. Set-Point Adjustment: Concealed.
 - 10. Set-Point Indication: Concealed.
 - 11. Thermometer: Concealed Spiral bimetal.
 - 12. Color: White.
 - 13. Orientation: Vertical.
 - 14. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
 - 15. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of minus 40 to plus 170 deg F (minus 40 to plus 76 deg C).
 - 16. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

2.16 STATUS SENSORS

- A. General:

1. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).
2. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
3. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
4. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
5. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
6. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
7. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
8. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.17 CURRENT TRANSMITTERS.

- A. AC current transmitters shall be the self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4 to 20 mA two-wire output. Unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A full scale, with internal zero and span adjustment and $\pm 1\%$ full-scale accuracy at 500 ohm maximum burden.
- B. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA Recognized.
- C. Unit shall be split-core type for clamp-on installation on existing wiring.

2.18 PRESSURE SENSOR AND TRANSDUCER

- A. General:
 1. Transducer shall have linear output signal. Zero and span shall be field adjustable.
 2. Transducer sensing elements shall withstand continuous operating conditions of positive or negative pressure 50% greater than calibrated span without damage.
 3. Water and steam pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and block and bleed valves.
 4. Water differential pressure transducer shall have stainless steel diaphragm construction, proof pressure of 150 psi minimum. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

2.19 ELECTRONIC AIR MEASURING STATION & HIGH PERFORMANCE CONTROL DAMPER

- A. These dampers are designated as AMD (electronic air measuring station and damper) and are prefixed with "O" for outdoor air service and "E" for exhaust air service on the control diagrams.
- B. Furnish and install a thermal dispersion airflow measuring station with integral damper and controls. The electronic thermal dispersion type airflow and temperature measuring station shall be capable of monitoring and reporting the airflow and temperature at each sensing point with up to 16 measuring probes containing 1 to 8 sensor points per probe. The AMD shall include a primary probe that interfaces with the building automation system (BAS) using BACNET protocol or 4-20mA (2-10V with included 500ohm resistors) analog outputs reporting velocity and temperature measurements.
- C. Primary probe shall be capable of processing up to 128 (16 probes, 8 sensors/probe each) independent sensing points per AMD. Probe(s) shall be constructed of an airfoil shaped for low pressure drop and low noise, acid-etch clear anodized 6063T6 aluminum extrusion. Each sensing point shall consist of two surface mounted thermistors on moisture resistant flexible polyimide substrate with one thermistor for velocity and one for ambient temperature.
- D. Primary probe shall feature a 16 character x 2 line alphanumeric backlit LCD display as the user interface. Menu shall support digital offset/gain adjustment when necessary to match test and balance measurements. The air measurement system shall include continuous sensor/transmitter diagnostics and activate a visual alarm if malfunctions are detected. Primary probe's user interface shall feature tool-free touch setup through a GUI on a hinged enclosure with dust tight and when required, weather resistant NEMA 4 construction. Primary probe's display shall be field configurable to display either I.P. or S.I. units. Factory calibration of thermal dispersion sensors shall be for the full range of velocities between 0 and 5,000 FPM. Proprietary cables are not acceptable. Factory wiring shall be completed using a composite 4 wire cable similar to Connect Air W24182P-2306BL with communications and power in one cable. Primary Control Probe output shall be BACnet® compatible with a field adjustable 4-20 mA, or 2-10 VDC across a 500ohm resistor. All electronic components of the assembly shall be lead-free RoHS compliant. Air measurement performance and accuracy statements shall be based on tests and procedures performed in accordance with AMCA publications 610 and 611.
 - 1. Airflow Measuring Accuracy shall be +/-3% over measuring range when installed per the manufacturer's installation guidelines.
- E. The assembly will require only a single point power connection for both the air measurement system and air measurement actuator and shall operate on a Class 2 24VAC or VDC low voltage supply.
- F. Air measuring and control shall include a leakage class 1A control damper. The complete assembly shall be fabricated, assembled, and calibrated in an ISO 9001 certified facility following strict ISO calibration test procedures.
- G. A factory furnished and calibrated air measurement system shall be programmed, with the job specific flow range. The controller shall report flow and damper position feedback via BACnet MS/TP or BACNet IP network interface with the building automation system.

- H. Velocity Requirements / Range: 0 to 5000 FPM measured through face area of damper.
- I. The BAS contractor shall coordinate proper sizing and placement of the air measuring station with a qualified manufacturer's representative prior to installation.
- J. The 180 in-lb air measurement actuator shall include integrated web server with two (2) analog inputs for flow sensing and receiving a DDC Setpoint. VAFB24-BAC is standard, spring return air measurement actuator model.
- K. Basis of design air measuring stations shall be, in all respects, equivalent to Ruskin AIRFLOW-IQ-TD-50-C.

2.20 HYDRONIC FLOW METERS

A. General Requirements for Liquid Flow Meters:

- 1. Adjustable for changes in system operational parameters.
- 2. Liquid and Steam Sensors, Meters, and Transmitters: Extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions.
- 3. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
- 4. Product certificates are required.

B. Insertion Electromagnetic Flow Meter:

- 1. Description:
 - a. No moving parts.
 - b. Suitable for flow measurement of fluids with electrical conductivity between 20 to 60000 micro-Seimens per centimeter.
 - c. Suitable for pipe sizes NPS 3 through NPS 72.
 - d. Wet calibrate and tag meters to standards traceable to NIST, and provide each meter with a certificate of calibration.
 - e. Continuous auto-zero function.
 - f. Transmitter integral to meter.
- 2. Performance:
 - a. Flow Range: 0.25 to 20 fps.
 - b. Accuracy for Velocities between 2 and 20 fps: Within 1 percent of reading.
 - c. Accuracy for Velocities Less than 2 fps: Within 0.02 fps.
 - d. Ambient Temperature: Minus 5 to 150 deg F.
 - e. Process Temperature: 15 to 250 deg F.
 - f. Pressure: 400 psig.
- 3. Output Signals:
 - a. Field-selectable analog signals.

- 1) Current Signal (Isolated): 4 to 20 mA.
 - 2) Voltage Signal (Isolated): Zero- to 10-V dc.
 - b. Digital Signal: Dry-contact closure signaling fault condition.
 - c. Frequency Signal: Zero- to 15-V peak pulse, zero to 500 Hz.
 - d. Scalable Pulse Output:
 - 1) Isolated solid-state dry contact.
 - 2) Contact Rating: 100 mA at 50-V dc.
 - 3) Pulse Duration: 0.5, 1, 2, or 6 seconds.
4. Construction:
 - a. Wetted Metal Parts: Type 316 stainless steel.
 - b. Sensor Head: Polysulfone.
 - c. Process Connection: 1-inch.
 - d. Instrument Isolation Valve: Full port Type 316 stainless steel ball valve for system isolation.
 - e. Electrodes: Type 316 stainless steel.
 - f. Electronics Enclosure:
 - 1) Painted aluminum.
 - 2) Removable cover.
 - 3) NEMA 250, Type 4.
 - 4) Electrical Connection: PVC-jacketed cable, 10 feet long.
 - 5) Conduit Connection: 1/2-inch trade size.

2.21 MANUFACTURER SUPPLIED REMOTE SENSORS

- A. Install all manufacturer supplied remote sensors. Sensors include, but are not limited to:

1. Space temperature sensors.
2. Discharge air temperature sensors.
3. Space humidity sensors.
4. Space CO2 sensors.
5. Duct static pressure sensors.
6. Building pressure sensors.

2.22 CONTROL VALVES

- A. General:

1. Control valves shall be two-way or three-way type for two-position or modulating service as shown.
2. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - a. Water Valves:

- 1) Two-way: 150% of total system (pump) head.
 - 2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
 - b. Steam Valves: 150% of operating (inlet) pressure.
3. Modulating 2-Way Water Valves:
- a. Pressure Independent Ball Valves NPS 2 and Smaller:
 - 1) Manufacturers: Subject to compliance with requirements, available manufactures offering products that may be incorporated into the Work include:
 - a) Belimo Aircontrols (USA), Inc
 - b) HCI; Hydronics Components Inc.
 - c) Siemens Industy, Inc (Building Technologies Division).
 - d) Tour and Anderson.
 - 2) Basis of Design: Belimo PIQCV.
 - 3) Performance:
 - a) Pressure Rating: 360 psig.
 - b) Process Tempeature Range: Between zero to 212°F.
 - c) Rangeability: 100 to 1.
 - 4) Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
 - 5) Body: Forged brass, nickel plated, and with threaded ends.
 - 6) Ball: Stainless steel.
 - 7) Stem and Stem Extension: Stainless steel, blowout proof design.
 - a) Stem sleeve or other approved means to allow valve to be opened and closed without damaging firdl-applied insulation and insulation vapor barrier seal.
 - 8) Ball Seats: Reinforced PTFE.
 - 9) Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
 - 10) Flow Characteristic: Equal percentage.
 - b. Pressure-Independent Ball Valves NPS 2-1/2 and Larger:
 - 1) Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include:
 - a) Belimo Aircontrols (USA), Inc.

- b) HCI; Hydronics Components Inc.
 - c) Siemens Industry, Inc. (Building Technologies Division).
 - 2) Basis of Design: Belimo EPIV or equal.
 - 3) Performance:
 - a) Pressure Rating: ANSI 125, Class B.
 - b) Close-off pressure of 100 psig.
 - c) Process Temperature Range: Between zero to 212 deg F.
 - d) Rangeability: 100 to 1.
 - 4) Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.
 - 5) Body: Cast iron, with flanged ends.
 - 6) Ball: Stainless steel.
 - 7) Stem and Stem Extension: Stainless steel, blowout-proof design.
 - 8) Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
 - 9) Ball Seats: Reinforced PTFE.
 - 10) Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
 - 11) Flow Characteristic: Equal percentage.
- 4. Two Position 2-Way Water Valves:
 - a. Ball Valves NPS 2 and Smaller:
 - 1) Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include:
 - a) Belimo Aircontrols (USA), Inc.
 - b) HCI; Hydronics Components Inc.
 - c) Siemens Industry, Inc. (Building Technologies Division).
 - 2) Sizing Criteria: Line size.
 - 3) Body: Forged brass, nickel plated, and with threaded ends.
 - 4) Ball: Stainless steel.
 - 5) Stem and Stem Extension: Stainless steel, blowout proof design.
 - a) Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
 - 6) Ball Seats: Reinforced PTFE.
 - 7) Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the

linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.

- 8) Flow Characteristic: Equal percentage.
- 9) Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
 - a) Water zone valves normally open preferred.
 - b) Heating coils in air handlers normally open.
 - c) Chilled water control valves normally closed.
 - d) Other applications as scheduled or as required by sequences of operation.

b. Butterfly Valves:

- 1) Performance:
 - a) Bi-directional bubble tight shutoff at 250 psig.
 - b) Comply with MSS SP-67 or MSS SP-68.
 - c) Rotation: Zero to 90 degrees.
 - d) Linear or modified equal percentage flow characteristic.
- 2) Body: Cast iron ASTM A126, Class B, ductile iron ASTM A536 or cast steel ASTM A216/A216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
- 3) Disc: 316 stainless steel.
- 4) Shaft: 316 or 17-4 PH stainless steel.
- 5) Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
- 6) Shaft Bushings: Reinforced PTFE or stainless steel.
- 7) Replaceable seat, disc, and shaft bushings.
- 8) Corrosion-resistant nameplate indicating:
 - a) Manufacturer's name, model number, and serial number.
 - b) Body size.
 - c) Body and trim materials.
 - d) Flow arrow.

5. 3-Way Water Valves:

- a. Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.
- b. Sizing Criteria:
 - 1) Two-position service: Line size.
 - 2) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 5 psi maximum.
- c. Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.

- d. Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
- e. Water valves shall fail normally open or closed, as scheduled on plans, or as follows:
 - 1) Water zone valves normally open preferred.
 - 2) Heating coils in air handlers normally open.
 - 3) Chilled water control valves normally closed.
 - 4) Other applications as scheduled or as required by sequences of operation.

6. Actuators

- a. The actuator shall have mechanical or electronic stall protection to prevent damage to the actuator throughout the rotation of the actuator.
- b. Where shown, for power-failure/safety applications, an internal mechanical, spring-return mechanism shall be built into the actuator housing. Alternatively, an uninterruptible power supply (UPS) may be provided.
- c. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range.
- d. All 24 VAC/VDC actuators shall operate on Class 2 wiring
- e. All non-spring-return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank for this purpose.

2.23 DAMPERS

- A. Dampers: AMCA-rated, parallel or opposed-blade design; 0.108-inch-minimum thick, galvanized-steel or 0.125-inch-minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall be airfoil shape and shall not be less than 0.064-inch-thick galvanized steel with maximum blade width of 8 inches and length of 48 inches.
 - 1. Secure blades to 1/2-inch-diameter, zinc-plated axles using zinc-plated hardware, with nylon blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 - 2. Operating Temperature Range: From minus 40 to plus 200 deg F.
 - 3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene, rated for leakage at less than 2 cfm per sq. ft. of damper area, at differential pressure of 1-inch wg for all sizes 24-inch wide or larger.
 - 4. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. of damper area, at differential pressure of 4-inch wg when damper is held by torque of 50 in. x lbf; when tested according to AMCA 500D.
 - 5. Control dampers shall be the parallel or opposed blade type as below or as scheduled on drawings.
 - a. Outdoor and/or return air mixing dampers and face and bypass (F&BP) dampers shall be parallel blade, arranged to direct airstreams toward each other.

- b. Other modulating dampers shall be the opposed blade type.
 - c. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.
- 6. Individual damper sections shall not be larger than 48 in. × 60 in. Provide a minimum of one damper actuator per section.
 - 7. Modulating dampers shall provide a linear flow characteristic where possible.
 - 8. Dampers shall have exposed linkages.

2.24 ACTUATORS

A. General:

- 1. Damper actuators on outside air intake and relief air locations shall be spring-return type and fail closed.
- 2. Valve actuators on heating water valve actuators in the path of outside air shall be spring-return type and fail open.
- 3. Operators shall be fully proportional type unless otherwise specified. The operators shall be capable of operating at varying rates of speed to correspond to the dictates of the controllers and variable load requirements.

B. Sizing:

- 1. Valves: Size for torque required for valve close off at maximum pump differential pressure.
- 2. Dampers: Provide individual operators for each damper section, no linkages shall be installed between dampers to transfer operator power. Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
 - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
 - g. De-rate manufacturer's catalog information at 50% for modulating damper applications.

C. Features:

- 1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
- 2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing.
- 3. All rotary spring return actuators shall be capable of both clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position.

4. Proportional actuators shall accept a 0-10 VDC or 0-20 ma control signal and provide a 2-10 VDC or 4-20 ma position feedback signal.
5. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
6. Actuators shall have external adjustable stops to limit the stroke.
7. Actuators shall be provided with a conduit fitting and a minimum 3 feet electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
8. Actuators shall be Underwriters Laboratories Standard 873 listed.
9. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque.
10. Temperature Rating: Minus 22 to plus 122 deg F.
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F.
12. Provide weather tight housing for actuators exposed to outdoor conditions.

2.25 CONTROL CABLE

- A. General: Provide electronic and fiber-optic cables for control wiring.

2.26 WIRING AND RACEWAYS

- A. General:
 1. Provide copper wiring, plenum cable, and raceways.
 2. All insulated wire to be copper conductors, UL labeled for 90°C minimum service.
 3. Power and Class 1 wiring may be run in the same conduit. Class 2, Class 3, and communications wiring may be run in the same conduit.
- B. Where different wiring classes terminate within the same enclosure, maintain clearances, and install barriers per the National Electric Code.
- C. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be a minimum ½-inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal-off fittings where exterior conduits enter the building or between areas of high temperature/moisture differential.
- D. Flexible metallic conduit shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment Liquid-tight flexible conduit shall be used in exterior location and interior locations subject to moisture.
 1. Maximum length of flexible conduit runs shall be 3-feet.
- E. Junction boxes shall be provided at all cable splices, equipment terminations, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal 4-inch square with blank cover. Exterior and damp locations J-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.
- B. Inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.
- C. Examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate or if any discrepancies occur between the plans and the contractor's work and the plans and the work of others the contractor shall report these discrepancies to the architect/engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by and at the expense of this contractor.
- D. Verify that power supply is available to control units.
- E. Verify that duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.
- F. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- G. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- H. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- I. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- J. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PROTECTION

- A. Protect all work and material from damage by his/her work or employees and shall be liable for all damage thus caused.
- B. Protect any material that is not immediately installed. Close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.3 COORDINATION

A. Site

1. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition without extra charge.
2. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

B. Test and Balance

1. Furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. Provide training in the use of these tools.
3. In addition, provide a qualified technician to assist in the test and balance process.
4. The tools used during the test and balance process will be returned at the completion of the testing and balancing.

C. Life Safety

1. Interlock smoke detectors to air handlers for shutdown as described in Operating Sequences on the Drawings.
2. Interlock these smoke dampers to the air handlers as described in Operating Sequences on the Drawings.
3. Control of fire/smoke dampers shall be by the fire alarm system.
4. Coordination with controls specified in other sections or divisions:
 - a. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the contractor.
 - b. Each supplier of a controls product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
 - c. The Contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
 - d. The contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
 - e. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

3.4 GENERAL WORKMANSHIP

- A. Install equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- C. Install all equipment in readily accessible locations as defined by Chapter 1, Article 100, Part A of the National Electrical Code (NEC).
- D. Verify integrity of all wiring to ensure continuity and freedom from shorts and grounds.
- E. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices.
- F. After purchase of NAC network controllers and prior to installation, the controllers' MAC addresses and anticipated installation location shall be provided to the owner for assignment of IP addresses and to begin the process of ethernet drop installation.
- G. Upon completion of NAC network controller check out, the architect/engineer shall be informed that the controller is available and ready for integration.

3.5 INSTALLATION

- A. Install system and materials in accordance with manufacturer's instructions, and as detailed on the project drawing set.
- B. Drawings of the BAS are diagrammatic only and any apparatus not shown, but required to make the system operative to the complete satisfaction of the architect/engineer shall be furnished and installed without additional cost.
- C. Install products level, plumb, parallel, and perpendicular with building construction.
- D. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway.
- E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Provide plastic laminated 11"x17" copies of all control drawings and Operating Sequences applicable to all controllers within any given control cabinet. Laminated copies of drawings shall be placed within a clear plastic Pocket Card attached to the inside door of each control cabinet. This requirement is in addition to the requirements indicated in Part 1, "Submittals."
- G. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Temperature Control sub-contractor in accordance with standard industry practices.

- H. Install software in control units. Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- I. Install programming application. Coordinate with owner on where software is to be installed.
- J. Connect and configure equipment and software to achieve sequence of operation specified.
- K. Damper motors shall be installed on the outside of duct in warm areas. Damper motors shall not be installed in locations exposed to outdoor temperatures.
- L. Install refrigerant instrument wells, valves, and other accessories according to standard industry practice.
- M. Install electronic and fiber-optic cables according to standard industry practice.

3.6 COMMUNICATION BACKBONE

- A. To allow for future expandability, cyber security measures, optimal bandwidth, and enhanced data trending this project shall adhere to the below communication backbone requirements.
- B. Fiber Optic Network
 - 1. Required for all project exceeding five levels (including rooftops/cellars), 300 feet between ethernet connections, 250 controllers, or more than one type of operational technology residing on the same network (CCTV, lighting, access, etc.).
 - 2. Network edge switches provided for each floor with provisions for expansion capability.
 - 3. Fiber optic cable shall be run between network switches.
 - 4. A centralized network controller with aggregation switch shall be provided for the building:
- C. Must be a managed fiber / ethernet network with the following network features:
 - 1. Packet switching and loop detection
 - 2. Port security with MAC address lockdown and the ability to close all open ports including port connected to a daisy-chain of IP devices.
 - 3. Segregation / isolation with VLAN configuration capabilities. The system shall allow system-wide auto-creation of a VLAN simply by specifying one or more ports to be on that VLAN, and automatically ensure that traffic passes between the selected ports. There must not be any restriction on port location.
 - 4. Web browser based graphical user interface for information logging (network overloads, bandwidth consumption, port status, connection status, and trending)
 - 5. Support both Ethernet and Power over Ethernet (PoE)
 - 6. Support fiber optic backbone(s) with Single-strand, Single-mode Optical Fiber OS1/OS2 9/125 μ m, up to 12.5 miles reach
 - 7. BACnet protocol specific network traffic support and support for all other communication protocols
 - 8. Expansion capability of up to 256 Edge Switches
 - 9. Edge Switches
 - a. Shall provide 1 per floor

- b. Must be compatible with Centralized Network Controller with Aggregation Switch and support the managed network features described above
- c. Support both Ethernet, Power over Ethernet (PoE), and Spanning Tree Protocol
- d. Support all communication protocols
- e. Minimum of eight RJ45 ethernet ports (all controllers on floor must be connected to Edge switch directly or via daisy-chain IP topology)

10. Security Provisions:

- a. Individual VLAN provided per every two levels

- D. Powered via UPS to maintain systems operation throughout short term power interruptions of up to 15 minutes duration.

3.7 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to requirements of Division 26.

- 1. Rough-in for thermostats shall be at 42 inches above finished floor.

- B. Install building wire and cable according to requirements of Division 26.

- C. Install signal and communication cable according to requirements of Division 28.

- 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path. Bundled cable shall be in neat and orderly fashion.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
 - 8. Where accessible ceilings are present, and where permitted by code and local authority, BAS cabling may be run open without raceway. In such cases, BAS cabling shall be plenum rated, and run parallel to or at right angles to the structure. It shall be properly supported by use of D rings, cable ties or other approved hangers and installed in a neat and workmanlike manner.

- D. All electrical control wiring and power wiring to the BAS, network components and control devices shall be the responsibility of the BAS contractor.

3.8 EXISTING EQUIPMENT

- A. The building and equipment, including equipment indicated to be demolished, are served by a variety of control systems. Where work is specified for demolition, all existing controls shall be

removed, including sensors, wiring, relays, actuators, controllers, control panels, and related ancillary and peripheral equipment and materials. In no case shall any items be left abandoned in place without obtaining written authorization from the architect/engineer or Owner.

- B. Where existing equipment, systems, controllers, and similar ancillary and peripheral equipment are not to be modified under this project they shall be protected and retained in service. In no case shall existing conduit, cabling, controllers, etc. formerly serving items to be demolished be reused for the new application without obtaining written authorization from the architect/engineer or Owner. Before discarding any controllers, and similar ancillary and peripheral equipment scheduled for demolition the contractors shall notify the Owner of such items demolished. Where directed, certain items shall be turned over to the Owner for use as spare parts.

3.9 INSTALLATION OF SENSORS

- A. Install sensors in accordance with the manufacturer's recommendations.
- B. Mount sensors rigidly and adequately for the environment within which the sensor operates.
 - 1. Mounting Height:
 - a. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
 - b. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements at no less than 42" or more than 60 inches above the adjacent floor, grade, or service catwalk or platform.
- C. Space Sensor Installation:
 - 1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
 - 2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
 - 3. In finished areas, recess electrical box within wall.
 - 4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
 - 5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.
 - 6. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
 - 7. Install wire guards on all wall sensors in spaces with athletic type activities.

- D. Sensors used in mixing plenums and hot and cold decks shall be of the averaging type. Averaging sensors shall be installed in a serpentine manner vertically across the duct. Each bend shall be supported with a capillary clip.
- E. Low-limit temperature sensors used in mixing plenums shall be installed in a serpentine manner horizontally across duct. Each bend shall be supported with a capillary clip. Provide 1 ft of sensing element for each 1 ft² of coil area.
- F. All pipe-mounted temperature sensors shall be installed in wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.
- G. Install outdoor air temperature sensors on north wall where effects of heat radiated from the building is minimized and complete with sun shield.
- H. Differential air static pressure.
 - 1. Pressure transmitters whose signal is utilized for maintaining duct static pressure shall be wired directly to the controller which modulates fan speed. Signal shall be completely independent of the control system network.
 - 2. Supply Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the high-pressure tap tubing of the corresponding building static pressure sensor (if applicable) or to the location of the duct high-pressure tap and leave open to the plenum.
 - 3. Return Duct Static Pressure: Pipe the high-pressure tap to the duct using a pitot tube. Pipe the low-pressure port to a tee in the low-pressure tap tubing of the corresponding building static pressure sensor.
 - 4. Building Static Pressure: Pipe the low-pressure port of the pressure sensor to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe the high-pressure port to a location behind a thermostat cover.
 - 5. The piping to the pressure ports on all pressure transducers shall contain a capped test port located adjacent to the transducer.
 - 6. All pressure transducers, other than those controlling VAV boxes, shall be located in field device panels, not on the equipment monitored or on ductwork. Mount transducers in a location accessible for service without use of ladders or special equipment.
 - 7. Hard pipe shall be used for final insertion of pressure ports through walls and into space or exterior of building.
- I. All air and water differential pressure sensors shall have gauge tees mounted adjacent to the taps. Water gauges shall also have shutoff valves installed before the tee.
- J. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.
- K. Furnish and install electrical power to products requiring electrical connections.

3.10 AIRFLOW MEASURING STATION INSTALLATION

- A. Coordinate with equipment manufacturer(s) on which airflow measuring stations will be factory installed.

- B. Provide start-up of all airflow measuring stations on project.

3.11 HYDRONIC FLOW METER INSTALLATION

A. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:
 - a. Install system process connections full size of meter connection, but not less than NPS 1. Provide bushing if required to mate to system connection.
 - b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
 - c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

3.12 CONTROL VALVE INSTALLATION

- A. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
- B. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.
- C. Valves shall be installed in accordance with the manufacturer's recommendations.
- D. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure, other pipes, equipment, or other building components.
- E. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.
- F. Provide tags for all control valves indicating service and number. Tags shall be brass, 1.5 inch in diameter, with ¼ inch high letters. Securely fasten with chain and hook. Match identification numbers as shown on approved controls shop drawings.
- G. Valves: Actuators shall be connected to valves with adapters approved by the actuator manufacturer. Actuators and adapters shall be mounted following the actuator manufacturer's recommendations.

3.13 CONTROL DAMPER INSTALLATION

- A. Coordinate with equipment manufacturer(s) on which dampers will be factory installed. Provide remainder of dampers.
- B. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
- C. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure $\frac{1}{4}$ in. larger than damper dimensions and shall be square, straight, and level.
- D. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 0.3 cm (1/8 in.) of each other.
- E. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
- F. Install extended shaft or jackshaft according to manufacturer's instructions. (Typically, a sticker on the damper face shows recommended extended shaft location. Attach shaft on labeled side of damper to that blade.) Use line shafting or shaft couplings (jackshafting) in lieu of blade-to-blade linkages or shaft coupling when driving axially aligned damper sections.
- G. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
- H. Provide a visible and accessible indication of damper position on the drive shaft end.
- I. Support ductwork in area of damper when required to prevent sagging due to damper weight.
- J. After installation of low-leakage dampers with seals, caulk between frame and duct or opening to prevent leakage around perimeter of damper.
- K. Mount and link control damper actuators according to manufacturer's instructions.
- L. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
 - 1. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, and then tighten the linkage.
- M. Check operation of damper/actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
- N. Provide all mounting hardware and linkages for actuator installation. Actuators shall be mounted outside of the airstream.

- O. The total damper area operated by an actuator shall not exceed 80% of the manufacturer's maximum area rating. Provide at least one actuator for each damper section. Each damper actuator shall not power more than 20 square feet of damper.

3.14 SMOKE DAMPER INSTALLATION

- A. Coordinate all smoke and smoke/fire damper installation, wiring, and checkout to ensure that these dampers function properly and that they respond to the proper fire alarm system general, zone, and/or detector trips. The contractor shall immediately report any discrepancies to the architect/engineer no less than two weeks prior to inspection by the code authority having jurisdiction.

3.15 IDENTIFICATION

- A. All wiring and cabling, including that within factory-fabricated panels, shall be labeled at each end within 5 cm (2 in.) of termination with the DDC address or termination number.
- B. All low voltage temperature control conduit shall be purple colored.
- C. In all cases, control identification shall match equipment tags nomenclature as indicated on the Contract Documents.
- D. Permanently label or code each point of field terminal strips to show the instrument or item served.
- E. Permanently label terminal air volume box controllers with the transformer number and location that they are served from. Label to be located inside the control enclosure on the terminal box.
- F. Permanently label all transformers serving terminal air volume boxes with the boxes that are served from the transformer. Label shall be located at the transformer.
- G. Permanently label control panels with minimum ½ in. letters on laminated plastic nameplates.
- H. Identify all other control components with permanent labels. All plug-in components shall be labeled such that removal of the component does not remove the label.
- I. Identify room sensors relating to terminal box or valves with nameplates.
- J. Manufacturers' nameplates and UL or CSA labels are to be visible and legible after equipment is installed.
- K. Identify equipment served by controllers in a panel with permanent label on the interior of the panel door.
- L. Identify location of sensors, equipment, and controllers above ceilings with mark in the corner of the ceiling tile used for access.

3.16 CONTROLLERS

- A. Provide a separate controller for each AHU or other HVAC system. A DDC controller may control more than one system provided that all points associated with the system are assigned to the same DDC controller. Points used for control loop reset, such as outside air or space temperature, are exempt from this requirement.
- B. Supply sufficient programmable controllers of all types to meet project requirements. Quantity and points contents to be approved by Owner prior to installation.
 - 1. Local Control Units (LCU) shall be utilized for primary mechanical and electrical systems such as Air handling equipment, Make-up Air Unit, Boiler System Control, and Chiller System Control type of applications.
 - 2. Terminal Control Units (TCU) shall be utilized for terminal equipment, such as Variable Air Volume, Fan Coil, Heat Pump, Roof Top, and Chilled Ceiling type of applications.
 - 3. Each LCU and TCU controller shall have a minimum of 10% spare capacity of each point type for future points. As a minimum, each controller shall have one spare of each point type available on the controller.
 - 4. Each NAC and each LAN shall not control more than 50% of their rated capacity.
 - 5. The LCU and TCU controller programming or configuration tools shall be fully accessible through the Operator Workstation and Web Browser Client.
 - 6. All LCUs and TCUs shall be furnished with extended memory. No LCU/TCU shall be provided with less than 128 MB of RAM.
- C. It is ultimately the exclusive responsibility of the systems integrator/building controls contractor to ensure that the NCU has adequate resources for the number of controllers attached to it.
- D. Each NAC shall be powered by a UPS to provide clean, reliable, noise-filtered power at all times and to protect and maintain systems operation throughout short term power interruptions of up to 15 minutes duration.
- E. Controller Identification:
 - 1. Shall be consistent throughout the project.

3.17 PROGRAMMING

- A. Network Area Controller user accounts:
 - 1. New installations are required to have two user accounts with administrator level privileges. The credential information shall be provided to the architect/engineer for distribution. The two additional accounts shall be as follows:
 - a. Owner.
 - b. Integration Contractor per Specification Section 250950 "Integration of Building Automation Systems," if this is a separate entity from programmer.
 - 2. To work on existing installations, request a user account in writing to the architect/engineer a minimum of 7 days in advance of the required need.

- B. To obtain remote access the BAS network, a written request shall be sent to the architect/engineer a minimum of 7 days in advance of the required need.
- C. Provide sufficient internal memory for the specified sequences of operation and trend logging. There shall be a minimum of 25% of available memory free for future use.
- D. Point Naming:
 - 1. System point names shall follow a consistent convention throughout the project.
 - 2. System point names shall match the submitted documents. This Point Naming Convention shall be adhered to without exception.
- E. Software Programming
 - 1. Provide programming for the system and adhere to the sequences of operation provided. All other system programming necessary for the operation of the system, but not specified in this document, also shall be provided by the contractor. Imbed into the control program sufficient comment statements to clearly describe each section of the program. The comment statements shall reflect the language used in the sequences of operation. Use the appropriate technique based on the following programming types:
 - a. Text-based:
 - 1) Must provide actions for all possible situations
 - 2) Must be modular and structured
 - 3) Must be commented
 - b. Graphic-based:
 - 1) Must provide actions for all possible situations
 - 2) Must be documented
 - c. Parameter-based:
 - 1) Must provide actions for all possible situations
 - 2) Must be documented
 - 2. The contractor shall be responsible for all costs, including that borne by the System Integrator, owner, or their consultants, for work related to non-compliance with following the software programming.

3.18 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect test, and adjust field-assembled components and equipment installation, including connections and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
6. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
7. Check temperature instruments and material and length of sensing elements.
8. Check control valves. Verify that they are in correct direction.
9. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.19 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.

- b. Check analog outputs using milliamper meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
 - 5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
 - 6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
 - 7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
 - 8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 - 9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 - 10. Provide diagnostic and test instruments for calibration and adjustment of system.
 - 11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
 - B. Adjust initial temperature and humidity set points.
 - C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during normal occupancy hours for this purpose.
- 3.20 CONTROL SYSTEM CHECKOUT AND TESTING
- A. Start-up Testing: All testing listed in this article shall be performed by the contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the owner's representative is notified of the system demonstration.
 - B. The contractor shall furnish all labor and test apparatus required to calibrate and prepare for service of all instruments, controls, and accessory equipment furnished under this specification.
 - C. Verify that all control wiring is properly connected and free of all shorts and ground faults. Verify that terminations are tight.

- D. Enable the control systems and verify calibration of all input devices individually. Perform calibration procedures according to manufacturers' recommendations.
- E. Verify that all binary output devices (relays, solenoid valves, two-position actuators and control valves, magnetic starters, etc.) operate properly and that the normal positions are correct.
- F. Verify that all analog output devices (I/Ps, actuators, etc.) are functional, that start and span are correct, and that direction and normal positions are correct. The contractor shall check all control valves and automatic dampers to ensure proper action and closure. The contractor shall make any necessary adjustments to valve stem and damper blade travel.
- G. Verify that the system operation adheres to the sequences of operation. Simulate and observe all modes of operation by overriding and varying inputs and schedules. Tune all DDC loops and optimum start/stop routines.
- H. Verify that NAC(s) properly power up, are properly licensed with all necessary application drivers, and patched into the local Ethernet drop. Coordinate directly with the owner to test that all ports are live and that the owner can see the NAC(s) on their network.
- I. Alarms and Interlocks:
 - 1. Check each alarm separately by including an appropriate signal at a value that will trip the alarm.
 - 2. Interlocks shall be tripped using field contacts to check the logic, as well as to ensure that the fail-safe condition for all actuators is in the proper direction.
 - 3. Interlock actions shall be tested by simulating alarm conditions to check the initiating value of the variable and interlock action.

3.21 ACCEPTANCE TESTING

- A. Perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications and the Sequence of Operation.
- B. Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after completed installation, system started up, and performing in-house tests.
- C. The tests described in this section are to be performed in addition to those tests performed as a necessary part of the installation, start-up, and debugging process and as specified in the "Control System Checkout and Testing" article in Part 3 of this specification. The owner's representative will be present to observe and review these tests. The architect/engineer shall be notified at least 10 days in advance of the start of the testing procedures.
- D. The demonstration process shall follow that approved in Part 1, "Submittals." The approved checklists and forms shall be completed for all systems as part of the demonstration.
- E. Provide at least two persons equipped with two-way communication and demonstrate actual field operation of each control and sensing point for all modes of operation including day, night, occupied, unoccupied, fire/smoke alarm, seasonal changeover, and power failure modes. The

purpose is to demonstrate the calibration, response, and action of every point and system. Provide and operate any test equipment required to prove the proper operation shall.

- F. As each control input and output is checked, a log shall be completed on an approved Point-to-Point Check-Out form showing the date, technician's initials, and any corrective action taken or needed.
- G. Demonstrate compliance with Part 1, "System Performance."
- H. Demonstrate compliance with sequences of operation through all modes of operation.
- I. Demonstrate complete operation of operator interface.
- J. Additionally, the following items shall be demonstrated:
 - 1. DDC loop response. The contractor shall supply trend data output in a graphical form showing the step response of each DDC loop. The test shall show the loop's response to a change in set point, which represents a change of actuator position of at least 25% of its full range. The sampling rate of the trend shall be from 10 seconds to 3 minutes, depending on the speed of the loop. The trend data shall show for each sample the set point, actuator position, and controlled variable values. Any loop that yields unreasonably under-damped or over-damped control shall be further tuned.
 - 2. Demand limiting: Supply a trend data output showing the action of the demand limiting algorithm. The data shall document the action on a minute-by-minute basis over at least a 30-minute period. Included in the trend shall be building kW, demand limiting set point, and the status of sheddable equipment outputs.
 - 3. Optimum start/stop: Supply a trend data output showing the capability of the algorithm. The change-of-value or change-of-state trends shall include the output status of all optimally started and stopped equipment, as well as temperature sensor inputs of affected areas.
 - 4. Interface to the building fire alarm system.
 - 5. Operational logs for each system that indicate all set points, operating points, valve positions, mode, and equipment status shall be submitted to the architect/engineer. These logs shall cover three 48-hour periods and have a sample frequency of not more than 10 minutes. The logs shall be provided in both printed and disk formats.
- K. Any tests that fail to demonstrate the operation of the system shall be repeated at a later date. The contractor shall be responsible for any necessary repairs or revisions to the hardware or software to successfully complete all tests.
 - 1. The contractor shall be responsible for all costs, including that borne by the System Integrator, owner or their consultants, for work related to additional visits to repeat demonstrations due to failure of initial demonstration.
- L. Acceptance
 - 1. All tests described in this specification shall have been performed to the satisfaction of both the architect/engineer and owner prior to the acceptance of the control system as meeting the requirements of completion. Any tests that cannot be performed due to circumstances beyond the control of the contractor may be exempt from the completion

requirements if stated as such in writing by the architect/engineer. Such tests shall then be performed as part of the warranty.

2. The system shall not be accepted until all forms and checklists completed as part of the demonstration are submitted and approved as required in Part 1, "Submittals."

3.22 CLEANING

- A. Clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.
- B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.
- C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be repaired to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

3.23 TRAINING

- A. Provide on-site or classroom training sessions as follows:
 1. A minimum of 8 hours training at building turn-over.
 2. A minimum of 4 hours training review session after 60 days of operation by the owner. This shall be scheduled with the owner at substantial completion.
- B. Train the designated staff of owner's representative(s). These objectives can be divided into three logical groupings. Participants may attend one or more of these, depending on level of knowledge required:
 1. Day-to-day Operators:
 - a. Proficiently operate the system
 - b. Understand control system architecture and configuration
 - c. Understand DDC system components
 - d. Understand system operation, including DDC system control and optimizing routines (algorithms)
 - e. Log on and off the system
 - f. Access graphics, point reports, and logs
 - g. Adjust and change system set points, time schedules, and holiday schedules
 - h. Recognize malfunctions of the system by observation of the printed copy and graphical visual signals
 - i. Understand system drawings and Operation and Maintenance manual
 - j. Understand the job layout and location of control components
 - k. Access data from DDC controllers.
 - l. Understanding typical alarms and how to address them as they occur.
 2. Advanced Operators:

- a. Make and change graphics on the workstation
 - b. Create, delete, and modify alarms, including annunciation and routing of these
 - c. Create, delete, and modify point trend logs and graph or print these both on an ad-hoc basis and at user-definable time intervals
 - d. Create, delete, and modify reports
 - e. Add, remove, and modify system's physical points
 - f. Create, modify, and delete programming
 - g. Add panels when required
 - h. Add operator interface stations
 - i. Create, delete, and modify system displays, both graphical and others
 - j. Perform DDC system field checkout procedures
 - k. Perform DDC controller unit operation and maintenance procedures
 - l. Perform workstation and peripheral operation and maintenance procedures
 - m. Perform DDC system diagnostic procedures
 - n. Configure hardware including PC boards, switches, communication, and I/O points
 - o. Maintain, calibrate, troubleshoot, diagnose, and repair hardware
 - p. Adjust, calibrate, and replace system components
3. System Managers/Administrators:
- a. Maintain software and prepare backups
 - b. Interface with job-specific, third-party operator software
 - c. Add new users and understand password security procedures
- C. Provide course outline and materials in accordance with the "Submittals" article in Part 1 of this specification. The instructor(s) shall provide one copy of training material per student.
- D. The instructor(s) shall be factory-trained instructors experienced in presenting this material.
- E. Classroom training shall be done using a network of working controllers representative of the installed hardware.
- F. Schedule training with at least 7 days advance notice.

3.24 SOFTWARE LICENSE

- A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). The owner, or the owner's appointed agent, shall determine which organizations to be named in the "orgid" of all Niagara Framework software licenses.
- B. The owner, or the owner's appointed agent, shall be free to direct the modification of the "orgid" in any Niagara Framework software license, regardless of supplier.
- C. The owner, or the owner's appointed agent, shall receive ownership of all job specific software configuration documentation, data files, and application-level software developed for the project. This shall include all custom, job specific software code and documentation for all configuration and programming that is generated for a given project and /or configured for use within Niagara Framework (Niagara) based controllers and/or servers and any related LAN / WAN / Intranet and Internet connected routers and devices. Any and all required Ids and passwords for access to any component or software program shall be provided to the owner.

3.25 WARRANTY ACCESS

- A. The Owner shall grant reasonable access to the building and automation system during the warranty period.
- B. Provide and implement a system for purposes of remote diagnostics and notification of desired exceptions. System shall provide the following functions:
 - 1. Controlled access to the entire facility control system to provide service and diagnostic support.
 - 2. Access by the owner from off-site for similar purposes and for remote operation, monitoring, and adjustment of functions.

END OF SECTION 230900

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Section 238316 "Radiant-Heating Hydronic Piping."

1.2 SUMMARY

- A. Section includes pipe and fitting materials and joining methods for the following:
 - 1. Hot-water heating piping.
 - 2. Makeup-water piping.
 - 3. Air-vent piping.
 - 4. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated including joining methods
- B. Hydronic system cleaning: Written report.
- C. Owner's chemical treatment supplier written test results of minimum of six (6) samples.
- D. Mechanical Contractor and Chemical Treatment Supplier "sign-off" that all the hydronic piping systems are clean, ready for service and have been accepted by the Owner.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit piping construction plans and mechanical room layout 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. Mechanical Rooms: Hydronic systems equipment including chillers, boilers, pumps, air separators, expansion tanks, water treatment equipment and all other hydronic specialties, indicating coordination with general construction, building components including structure, duct, plumbing, and sprinkler piping, electrical conduits, and other building services.
 - 2. Building piping installation, indicating coordination with general construction, building components including structure, duct, plumbing, and sprinkler piping, electrical conduits,

- and other building services. Indicate proposed sizes, elevations, changes in elevation, etc.
- 3. Suspended ceiling components.
- 4. Size and location of access to concealed equipment.
- 5. Penetrations of smoke barriers and fire-rated construction.
- B. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 - 1. Hot-Water Heating Piping: 100 psig at 200 deg F.
 - 2. Makeup-Water Piping: 80 psig at 150 deg F.
 - 3. Air-Vent Piping: 200 deg F (93 deg C).
 - 4. 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. Type M (Type C), drawn-temper copper tubing, wrought-copper fittings, and soldered joints
- B. Copper or Bronze Pressure-Seal Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. NIBCO INC.
 - b. Viega.
 - 2. Housing: Copper.
 - 3. O-Rings and Pipe Stops: EPDM.
 - 4. Tools: Manufacturer's special tools.
 - 5. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).

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. Cold Press Mechanical Joint Fittings: Fittings shall be by Viega and shall conform to material requirements of ASTM A420 or ASME B16.3 and performance criteria of IAPMO PS117 and ASTM F3226. Sealing elements for press fittings shall be FKM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have Smart Connect® technology design. MegaPress fittings with the Smart Connect technology assure leakage of liquids and/or gases from inside the system past the sealing element of an unpressed connection.
- D. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International, Inc.
 - b. Central Sprinkler Company.
 - c. Star Pipe Products.
 - d. Victaulic Company.
 - 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 or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- E. Mechanical Couplings for Joining Carbon Steel Pipe
 - 1. Standard Mechanical Couplings, 2 inch (DN50) through 12 inch (DN300): Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. (Gaskets used for potable water applications shall be UL classified in accordance with ANSI/NSF-61 for potable water service.) Mechanical Coupling bolts shall be zinc plated (ASTM B-633) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183, minimum tensile strength 110,000 psi (758450 kPa).
 - a. Rigid Type: Coupling housings with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance with ANSI B31.1, B31.9, and NFPA 13.

- 1) 2 Inch (DN50) through 12 Inch (DN300): Installation ready rigid coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C).
 - 2) 10 Inch (DN250) through 12 Inch (DN300): Standard rigid coupling. Gasket shall be Grade "E" EPDM compound with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C).
- b. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Flexible couplings may be used in lieu of flexible connectors at equipment connections. Three couplings, for each connector, shall be placed in close proximity to the vibration source.
 - 1) 2 Inch (DN50) through 8 Inch (DN200): Installation ready flexible coupling for direct stab installation without field disassembly. Gasket shall be Grade "EHP" EPDM compound with red color code designed for operating temperatures from -30 deg F (-34 deg C) to +250 deg F (+120 deg C).
 - 2) 10 Inch (DN250) through 12 Inch (DN300): Gasket shall be Grade "E" EPDM compound with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C).
2. Flange Adapters: For use with grooved end pipe and fittings, flat faced, for mating to ANSI Class 125 / 150 flanges.
3. Grooved couplings shall meet the requirements of ASTM F-1476.
4. Gasket: Synthetic rubber conforming to steel pipe outside diameter and coupling housing, manufactured of elastomers as designated in ASTM D-2000.
5. AGS Mechanical Couplings, 14 inch (DN350) through 60 inch (DN1500): Couplings shall consist of two ASTM A-536 ductile iron housing segments, a wide elastomer pressure responsive gasket, and zinc electroplated carbon steel track head bolts and nuts conforming to the physical and chemical requirements of ASTM A-449 and the physical requirements of ASTM A-183.
 - a. Coupling housings designed with the wedge-shaped AGS key profile to engage the mating pipe(s)/component(s) wedge-shaped AGS grooves. Housings include lead-in chamfer to accommodate a wider acceptable range of initial pipe positions. Housings shall be coated with orange enamel or galvanized.
 - b. Gasket: Wide width, pressure-responsive, synthetic rubber of a FlushSeal design, conforming to steel pipe outside diameter and coupling housing, manufactured of elastomers as designated in ASTM D-2000.
 - 1) Grade "E" EPDM with green color code designed for operating temperatures from -30 deg F (-34 deg C) to +230 deg F (+110 deg C).
 - 2) Grade "T" Nitrile with orange color code designed for operating temperatures from -20 deg F (-29 deg C) to +180 deg F (+82 deg C).
 - 3) Grade "L" Silicone with red color code designed for operating temperatures of -30 deg F (-34 deg C) to +350 deg F (+177 deg C); recommended for dry heat service (air without hydrocarbons).
 - 4) Reference shall always be made to the latest published Selection Guide for for proper gasket selection for the intended service.

c. Coupling Types:

- 1) Rigid Coupling: Coupling key shall be designed to fill the wedge shaped AGS groove to provide a rigid joint that corresponds with support spacings as defined by ASME B31.1 and B31.9. Systems incorporating rigid couplings require the calculated thermal growth/contraction of the piping system to be fully compensated for in the design of the piping system through use of adequate flexible components.
- 2) Flexible Coupling: Coupling key shall be designed to fit into the wedge shaped AGS groove and allow for linear and angular movement, vibration attenuation, and stress relief.
- 3) Flange Adapter 14 inch (DN350) to 24 inch (DN600): For use with AGS grooved end pipe and fittings, flat faced, for mating to ANSI Class 125 / 150 flanges.

F. Grooved End Fittings:

1. Standard fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45-12, forged steel conforming to ASTM A-234, Grade WPB 0.375" wall (9.53 mm wall), or fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fittings provided with an alkyd enamel finish or hot dip galvanized to ASTM A-153. Zinc electroplated fittings and couplings conform to ASTM B633.
2. AGS Fittings shall be supplied with factory AGS grooved ends. Fittings shall be manufactured of ductile iron conforming to ASTM A-536, forged carbon steel conforming to ASTM A-234, or factory fabricated from carbon steel pipe conforming to ASTM A-53. Fittings shall be manufactured to the dimensional standards ASME B16.9. Orange enamel coated or galvanized.
3. Hole-Cut Branch Outlets:
 - a. Bolted Branch Outlet: Branch reductions on 2 inch (DN50) through 8 inch (DN200) header piping. Bolted branch outlets shall be manufactured from ductile iron conforming to ASTM A-536, Grade 65-45-12, with synthetic rubber gasket, and heat treated carbon steel zinc plated bolts and nuts conforming to physical properties of ASTM A-183.
 - b. Strapless Outlet: 1/2 inch (DN15) or 3/4 inch (DN20) NPT outlet on 4 inch (DN100) and larger header sizes rated for 300 PSI (2065 kPa).
 - c. Strapless Thermometer Outlet: To accommodate industrial glass bulb thermometers with standard 1-1/4"-18 NEF 2B extra fine thread and 6-inch (152mm) nominal bulb length on 4-inch (DN100) and larger header sizes rated for 300 psi (2065 kPa).

G. Grooved Mechanical Joint Fitting and Coupling Installation:

1. Pipe ends shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove for proper gasket sealing.
2. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified.
3. Install the AGS piping system in accordance with the manufacturer's instructions.

4. AGS products shall not be installed with standard grooved end pipe or components. (Installing AGS products in combination with standard grooved end products could result in joint separation and/or leakage.)
5. Use grooving tools with AGS roll sets to groove the pipe. Follow the manufacturer's guidelines for tool selection and operation.
6. Couplings installation shall be complete when visual metal-to-metal contact is reached.

H. Steel Pressure-Seal Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Victaulic Company.
 - b. Viega.
2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig (2070-kPa) working-pressure rating at 230 deg F (110 deg C).

2.4 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 (3.2-mm) 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. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. A.Y. McDonald Mfg. Co.
- b. Capitol Manufacturing Company.
- c. Central Plastics Company.
- d. Hart Industries International, Inc.
- e. Jomar International Ltd.
- f. Matco-Norca.
- g. Watts Regulator Co.
- h. Victaulic Company Of America.
- i. Zurn Industries, LLC.

C. Dielectric Waterways

1. 1/2 inch (DN15) through 4 inch (DN100) sizes, IPS to copper-tubing size dielectric transition fitting. Fittings shall be a copper-silicon casting conforming to UNS C87850, and UL classified in accordance with ANSI / NSF-61 for potable water service. Fittings shall have threaded ends, grooved ends, or a combination.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

1. 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.
2. Threaded Brass to PEX-a Transition: One-piece brass fitting with male or female threaded adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Typically used for PEX sizes 3 inch and below.
3. Brass Sweat to PEX-a Transition: One-piece brass fitting with sweat adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Typically used for PEX sizes 3 inch and below.

B. Plastic-to-Metal Transition Unions:

1. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:

1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, or pressure-seal joints.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
3. Schedule 40 steel pipe; Cold press mechanical joint fittings

B. Hot-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be any of the following:

1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered or 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 40 steel pipe; cold press mechanical joint fittings (up to NPS 4)
- C. Makeup-water piping installed aboveground shall be the following:
1. Type L (Type B), drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- D. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
 2. Outlet: Type K (Type A), annealed-temper copper tubing with soldered or flared joints.
- E. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

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 on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.

- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 (DN 65) 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 Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors.
- V. Install sleeve seals for piping penetrations of concrete walls and slabs.
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- X. Quality Assurance
 - 1. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

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 (DN 50) and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.

- D. Dielectric Fittings for NPS 5 (DN 125) and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, 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 (6 m) long.
 2. Adjustable roller hangers for individual horizontal piping 20 feet (6 m) or longer.
 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) 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.
- C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
 2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
 3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
 4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).
 5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
 6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).
- D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
 2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
 3. NPS 1-1/4 (DN 32): Maximum span, 7 feet (2.1 m); minimum rod size, 3/8 inch (10 mm).
 4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
 6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
 7. NPS 3 (DN 80) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
- E. Polypropylene Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

- F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- G. Support vertical runs at roof, at each floor, and at 10-foot (3-m) 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. 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. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- F. 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.

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.
- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with details on the plans.

3.7 FLUSHING AND CLEANING PIPING SYSTEMS

- A. Upon completion of the hydronic piping systems installation, the Mechanical Contractor shall thoroughly clean the hydronic piping systems under the supervision of the Owner's chemical treatment supplier.
- B. Initial Flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 6 feet per second, if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps.
- C. Cleaning: Using appropriate detergents and products, circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 6 feet per second. Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.
- D. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up water. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.
- E. The start-up pump suction diffuser strainers shall be removed after cleaning of the hydronic systems is complete. Twenty percent (20%) of all other strainers in the hydronic systems shall be removed and inspected in the Owner's/Facility Director's presence. Should ten percent (10%) of the strainers inspected be found to have debris captured in the strainer, the Mechanical Contractor shall remove, clean, and replace all strainers in the hydronic piping systems. A written report shall be prepared by the Mechanical Contractor and submitted, through the General Contractor/Project Construction Manager, to the Owner upon completion of the cleaning of the system strainers.
- F. Once the strainers have been confirmed that they are clean, the Owner's chemical treatment supplier shall have multiple water samples, minimum of six (6) samples for each hydronic system, TESTED. The written test results shall be given to the Owner and to the Engineer of Record, and the results fully explained to both by the chemical treatment supplier.
- G. Upon acceptance by the Owner; the Owner, General Contractor/Project Construction Manager, Mechanical Contractor and Chemical Treatment Supplier shall "sign-off" that all the hydronic piping systems are clean, ready for service and have been accepted by the Owner.

- H. The General Contractor/Project Construction Manager shall be fully responsible for managing this process.

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 but not less than 100 psi. 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 60 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:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

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END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes special-duty valves and specialties for the following:

1. Hot-water heating piping.
2. Makeup-water piping.
3. Condensate-drain piping.
4. Air-vent piping.
5. Air control devices
6. Safety-valve-inlet and -outlet piping.
7. Flexible supply & return hoses

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. ASME Compliance: 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.
- B. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

- C. A factory trained representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation.
- D. A manufacturer's representative shall periodically visit the job site and review installation. Contractor shall remove and replace any improperly installed products.
- E. All grooved components shall conform to local code approval and/or as listed by ANSI-B-31.1, B-31.3, B-31.9, ASME, UL/ULC, FM, IAPMO or BOCA.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 - 1. Hot-Water Heating Piping: 150 psig at 200 deg F (93 deg C).
 - 2. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
 - 3. Condensate-Drain Piping: 150 deg F (66 deg C).
 - 4. Air-Vent Piping: 200 deg F (93 deg C).
 - 5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 AIR-CONTROL DEVICES

- A. Manual Air Vents:
 - 1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 - d. Flo Fab
 - e. Nexus Valve, Inc.
 - f. Taco, Inc.
 - 2. Body: Bronze.
 - 3. Internal Parts: Nonferrous.
 - 4. Operator: Screwdriver or thumbscrew.
 - 5. Inlet Connection: NPS 1/2 (DN 15).
 - 6. Discharge Connection: NPS 1/8 (DN 6).
 - 7. CWP Rating: 150 psig (1035 kPa).
 - 8. Maximum Operating Temperature: 225 deg F (107 deg C).
- B. Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Amtrol, Inc.
 - b. American Wheatley
 - c. Armstrong Pumps, Inc.
 - d. Bell & Gossett Domestic Pump.
 - e. Flo Fab
 - f. Taco, Inc.
2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature, with taps in bottom of tank for tank fitting. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. (379-L) unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig (860-kPa) working pressure and 250 deg F (121 deg C) maximum operating temperature.
4. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig (860-kPa) working pressure and 240 deg F (116 deg C) maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

C. In-Line Air-Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, provide the product scheduled on the plans by:
 - a. Spirotherm, Inc.,
2. Furnish and install as shown on the drawings and schedule a full flow coalescing type combination air eliminator and dirt separator.
3. Selection shall be based upon system flow with pipe size as a minimum in accordance with the basis of design. In no case shall entering velocity exceed 10 feet per second.
4. Separator shall be fabricated steel, rated for 150 psig working pressure, stamped and registered in accordance with ASME Section VIII, Division 1 for unfired pressure vessels, and include two equal chambers above and below the inlet / outlet nozzles.
5. The air and dirt removal device shall remove air down to 18 microns and shall remove dirt/debris down to 35 microns. The unit shall be 100% efficient at removing dirt down to 90 microns in 100 passes or less.
6. Each unit shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism.
7. A blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow low down and cleaning.

2.3 HYDRONIC PIPING SPECIALTIES

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 (DN 50) and smaller; flanged ends, or grooved for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig (860 kPa).
5. Allow sufficient length for installation. Where space is limited and for larger piping applications, consider using flexible joints and spherical connector

B. Flexible supply and return hoses

1. Suitable for use in Chilled Water and Hot Water Systems, up to 50% Glycol.
2. All hoses shall be equipped with swivel end connections at terminal unit. All end connections shall be crimped to meet standard pressure ratings. Serrated/Slip fit connections shall not be acceptable.
3. Hose material shall be stainless steel braided over a synthetic polymer liner.
4. Hoses shall meet or exceed the ASTM-D380-83 standard.
5. Hoses shall meet or exceed flame retardant testing per standards UL #723, NEPA #225, ANSI 2.5, UBC 42-1, and ASTM-E84A after ten minutes.
6. Insulated Hoses
 - a. Hose materials shall be high quality polyethylene pipe insulation over a stainless steel braided inner core.

C. Expansion Fittings: Comply with requirements in other sections of the specifications.

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install automatic flow control valves in the return pipe of each heating or cooling terminal.
- C. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- D. 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.
- E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 (DN 50) and larger.
- D. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - 1. Install tank fittings that are shipped loose.
 - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- E. Vent and purge air from hydronic system, and ensure that the expansion tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

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SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Close-coupled, in-line centrifugal pumps.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pump.
- B. Shop Drawings: For each pump.
 - 1. Show pump layout and connections.
 - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE:

- A. All pumps must have a pump efficiency index (PEI) less than or equal to one where required per DOE regulations.
- B. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified, or as denoted on the drawings.
- C. Ensure pump operation at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate to ANSI/HI 9.6.3.1 standard for Preferred Operating Region (POR) unless otherwise approved by the engineer. The pump NPSH shall conform to the ANSI/HI 9.6.1-1997 standards for *Centrifugal and Vertical Pumps for NPSH Margin*.

- D. Ensure pump pressure ratings are at least equal to system's maximum operating pressure at point where installed, but not less than specified.
- E. Equipment manufacturer shall be a company specializing in manufacture, assembly, and field performance of provided equipment with a minimum of 20 years experience.
- F. Equipment provider shall be responsible for providing certified equipment start-up and, when noted, an in the field certified training session. New pump start-up shall be for the purpose of determining pump alignment, lubrication, voltage, and amperage readings. All proper electrical connections, pump's balance, discharge and suction gauge readings, and adjustment of head, if required. A copy of the start-up report shall be made and sent to both the contractor and to the Engineer.

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 - 1. Armstrong Pumps Inc.
 - 2. Flo Fab
 - 3. Grundfos Pumps Corporation.
 - 4. ITT Corporation; Bell & Gossett.
 - 5. PACO Pumps.
 - 6. Patterson Pump Co.
 - 7. TACO Incorporated.
 - 8. Wilo
- B. Description
 - 1. The pumps shall be of a horizontal, permanently lubricated type, specifically designed for quiet operation. Suitable for 225° F operation at 175 PSIG working pressure. The pump shall be single stage, vertical split case design, in cast iron bronze fitted (or all bronze) construction. The pump internals shall be capable of being serviced without disturbing piping connections.

2. The pumps shall be composed of three separable components a motor, bearing assembly, and pump end (wet end). The motor shaft shall be connected to the pump shaft via a replaceable flexible coupler.
3. The pumps shall have a solid SAE1144 steel shaft supported by two sealed ball bearings. A non-ferrous shaft sleeve shall be employed to completely cover the wetted area under the seal.
4. Pump shall be equipped with an internally-flushed mechanical seal assembly. Seal assembly shall be the unitized type with stainless steel drive tabs, EPR bellows and seat gasket, stainless steel spring, and be of a carbon silicon-carbide design with the carbon face rotating against a stationary silicon-carbide face.
5. Bearing assembly shaft shall connect to either a cast bronze impeller. Impeller shall be hydraulically and dynamically balanced, keyed to the shaft and secured by a locking capscrew or nut.
6. A flexible type coupling shall be employed between the pump and motor.
7. Pump should be designed to allow for true back pull-out access to the pump's working components for ease of maintenance.
8. Pump volute shall be of cast iron design for heating systems or cast bronze for domestic water systems. The connection style on cast iron and bronze pumps shall be flanged. Volute shall include gauge ports at nozzles, and vent and drain ports.
9. To ensure alignment the motor shall be mounted to the bearing assembly via a bolted motor bracket assembly, and a rubber motor mount shall be used to assist in aligning the motor shaft with the pump shaft.
10. Motors shall meet scheduled horsepower, speed, voltage, and enclosure design. Motors through 1 HP shall be resilient mounted, motors over 1.5 HP shall be rigid mounted. Motors shall have permanently lubricated ball bearings and must be completely maintenance free. Motors shall be non-overloading at any point on the pump curve and shall meet NEMA specifications.
11. Pump shall be of a maintainable design and for ease of maintenance should use machine fit parts and not press fit components.
12. Pump manufacturer shall be ISO-9001 certified and be of U.S. manufacturer.
13. Each pump shall be factory tested and name-plated before shipment and shall be provided with a (3) year warranty from date of installation.

C. Capacities and Characteristics: As indicated on the equipment schedules on the plans.

2.2 PUMP SPECIALTY FITTINGS

A. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig (1204-kPa) pressure rating, cast-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- 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. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and spring hangers of size required to support weight of in-line pumps.
 - 1. Comply with requirements for hangers and supports specified in other sections of the specifications.

3.2 ALIGNMENT

- A. Engage a factory-authorized service representative to perform alignment service.
- B. 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.

3.3 CONNECTIONS

- A. 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 triple-duty valve on discharge side of pumps.
- F. Install suction diffuser and shutoff valve on suction side of pumps.
- G. Install flexible connectors on suction and discharge sides of pumps between pump casing and valves.

- H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- I. Ground equipment according to Division 26.
- J. Connect wiring according to Division 26.
- K. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

END OF SECTION 232123

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SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
 - 2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
 - 3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit piping construction 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. Refrigerant piping installation, indicating sizes, fittings, accessories and all equipment, coordinated with general construction, building components including structure, duct, plumbing, and sprinkler piping, electrical conduits, cable trays, and other building services. Indicate proposed sizes, elevations, changes in elevation, supports, etc.
 - 2. Suspended ceiling components.
 - 3. Size and location of access to concealed equipment.
 - 4. Penetrations of smoke barriers and fire-rated construction.

1.5 PRODUCT DELIVERY, STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.
- B. Pipe and tube required by the applicable standard to be cleaned and capped shall be delivered to the job site with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

- C. Protect stored pipe and tube from moisture and dirt. Elevate above grade. When stored inside, do not exceed the structural capacity of the floor.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L or ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
 - 5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig (3450 kPa).
 - 7. Maximum Operating Temperature: 275 deg F (135 deg C).
- B. Packed-Angle Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze.
 - 2. Packing: Molded stem, back seating, and replaceable under pressure.
 - 3. Operator: Rising stem.
 - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.

5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).
8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig (3450 kPa).

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 115-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.

3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F (4.4 deg C).
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: 450 psig (3100 kPa).

H. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

I. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

J. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

K. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: 25 tons.
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina.
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: 2 psig (14 kPa).
8. Rated Flow: 25 tons.
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.3 REFRIGERANTS

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. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 GENERAL

- A. Provide and install refrigerant piping and all required accessories sized and installed as recommended by the refrigeration equipment manufacturer.
- B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems.
- C. Install piping at indicated slope of 1" in 100' pitched to the indoor unit
- D. Install components having pressure rating equal to or than system operating pressure.

- E. Install piping free of sags, traps or kinks.
- F. Piping Joint Construction
 - 1. Ream ends of pipe and tube and remove burrs to restore full inside diameter.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe, tube, and fittings before assembly.
- G. Piping Protection: Except as otherwise indicated protect piping as specified below:
 - 1. Allowance for thermal expansion and contraction shall be provided for copper and copper alloy tube, passing through a wall, floor, ceiling or partition by wrapping with an approved pipe insulation of a minimum 3/4" wall thickness, and by installing through an appropriately sized sleeve to allow for thermal movement.
 - 2. Protection against abrasion shall be provided where copper and copper alloy tube comes in contact with other building members by wrapping with an approved pipe insulation of a minimum 1/2" wall thickness, pipe insulation will be in addition to the pipe isolation thickness.

3.2 PIPING APPLICATIONS

- A. Hot-Gas, Liquid, and Suction Lines:
 - 1. NPS 5/8 and Smaller shall be any of the following:
 - a. Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.
 - b. Copper, Type ACR, annealed tubing and wrought-copper fittings with soldered joints. Linesets pre-insulated with closed cell elastomeric insulation meeting the insulation requirements shown on the plans may be used.
 - 2. NPS 3/4 and Larger shall be any of the following:
 - a. Copper, Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.3 VALVE AND SPECIALTY APPLICATIONS

- A. Install packed-angle valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at strainers if they are not an integral part of strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.

- E. Install a full-sized, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- L. Install flexible connectors at compressors.

3.4 PIPING INSTALLATION

- A. Provide, size and install refrigerant piping and all required accessories as recommended by the refrigeration equipment manufacturer.
- B. Condensing units greater than 10 Tons or long line applications– obtain recommended refrigerant line sizing from a manufacturer's factory authorized representative.
- C. Install refrigerant piping according to ASHRAE 15.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

- G. Install piping adjacent to machines to allow service and maintenance.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- S. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

3.5 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- B. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.6 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports."
- B. Install the following pipe attachments:
 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 1. NPS 1/2 (DN 15): Maximum span, 60 inches; minimum rod size, 3/8 inch.
 2. NPS 5/8 (DN 18): Maximum span, 60 inches; minimum rod size, 3/8 inch.
 3. NPS 1 (DN 25): Maximum span, 72 inches; minimum rod size, 3/8 inch.
 4. NPS 1-1/4 (DN 32): Maximum span, 84 inches; minimum rod size, 3/8 inch.
 5. NPS 1-1/2 (DN 40): Maximum span, 96 inches; minimum rod size, 3/8 inch.
 6. NPS 2 (DN 50): Maximum span, 96 inches; minimum rod size, 3/8 inch.
 7. NPS 2-1/2 (DN 65): Maximum span, 108 inches; minimum rod size, 3/8 inch.
 8. NPS 3 (DN 80): Maximum span, 10 feet; minimum rod size, 3/8 inch.
 9. NPS 4 (DN 100): Maximum span, 12 feet; minimum rod size, 1/2 inch.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 1. Comply with ASME B31.5, Chapter VI.
 2. Test refrigerant piping and specialties. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials and retest until satisfactory results are achieved.

3.8 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
 - 4. Charge system with a new filter-dryer core in charging line.

3.9 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Verify that compressor oil level is correct.
 - 2. Open compressor suction and discharge valves.
 - 3. Open refrigerant valves except bypass valves that are used for other purposes.
 - 4. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232301 – VARIABLE REFRIGERANT FLOW SYSTEM REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Refrigerant pipes and fittings.
 - 2. Refrigerant piping valves and specialties.
 - 3. Refrigerants.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of copper tube, valve and piping specialty.
 - 1. Copper tube
 - 2. Isolation service valves
 - 3. Bypass filters
 - a. Including pressure drop, based on manufacturer's test data
 - 4. Floating and fixed mount piping supports
- B. Shop Drawings:
 - 1. A scaled coordination drawing shall be created by the mechanical contractor. Drawing shall indicate actual proposed routing of all piping, accurate equipment locations, vertical distances, obstacles requiring rises or dips, expansion loops (or other means), etc. Installation of piping and equipment shall not commence until drawing is approved by the engineer, and the manufacturer's representative updates system sizing (pipe sizes, refrigerant trim charge, etc.) per the drawing. Piping plans contained in these construction documents are schematic in nature.
- C. As Built Drawings:
 - 1. A scaled coordination drawing shall be submitted by the mechanical contractor. Drawing shall indicate as built routing of all piping, accurate equipment locations, vertical distances, obstacles requiring rises or dips, expansion loops, pipe sizes, Y-branch locations, isolation valve locations, and elevations above finished floor.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data:

1. The VRF system shall be installed by a licensed mechanical contractor.
2. The Contractor shall have a minimum of three (3) years' experience installing VRF Systems and have installed a minimum of ten (10) comparable projects using the manufacturer's product.
3. All personnel installing the VRF system shall have completed the manufacturer's installation training course within the previous two (2) years, including training on all equipment, piping, controls, and accessories indicated and furnished for installation.
 - a. A copy of each person's certificate of completion shall be submitted and a copy retained on file with the general contractor at the jobsite.
4. All personnel installing the VRF piping shall be medical gas certified ASSE 6010.
 - a. A copy of each person's certificate of completion shall be submitted and a copy retained on file with the general contractor at the jobsite.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: Bypass filters

B. As-built drawings

1. Piping system floor plans
2. Manufacturer pipe sizing diagrams

1.6 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 WARRANTY:

- A. Mechanical contractor shall provide a labor warranty for a period of five (5) years from the date of project turnover. Warranty shall cover the repair of refrigerant leaks, defects in piping or workmanship, replacement of failed components, and any lost refrigerant, during the warranty period.
- B. Any time a refrigerant leak is repaired, or the refrigerant system is opened for replacement of components:
 1. Existing refrigerant shall be weighed out and noted.
 2. After repairs are made, the entire system shall be pressure and vacuum tested to manufacturer's specifications.

3. After system passes pressure and vacuum tests, system shall be charged with virgin refrigerant to the manufacturer's specifications (total system charge).

C. Warranty excludes routine maintenance.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube:

1. Hard Copper:
 - a. ASTM B 280, Type ACR.
 - b. Manufactured in straight length hard tube
 - c. Plugged and charged with nitrogen
 - d. B-280/B-819 cleanliness requirement
2. Soft Copper:
 - a. Commercial grade refrigeration tubing (ASTM B743 and ASTM B88)
 - b. No. C122200 DHP (phosphorous deoxidized, high residual phosphorus)

B. Wrought-Copper Elbows: ASME B16.22, long radius

C. Wye Branches: Provided by equipment manufacturer.

D. Headers: Provided by equipment manufacturer.

E. Brazing Filler Metals:

1. AWS A5.8, Type BCuP-5; 15% silver content, 5% phosphorus content.
2. No flux or soldering allowed.

2.2 VALVES AND SPECIALTIES

A. Service / Isolation Valves:

1. Body: Forged brass-oven brazed with brass cap covering schrader core
2. Stainless Steel Ball
3. PTFE Seal Technology (Twice Sealing on Valve Stem)
4. Core: Removable ball-type check valve with stainless-steel spring.
5. PTFE Seat
6. End Connections: Brazed
7. Maximum Working Pressure:
 - a. 900 PSIG (1/4" thru 7/8")
 - b. 700 PSIG (1-1/8" thru 2-1/8").

8. Operating Temperature Range: -40C to 150C
9. Bidirectional Flow

B. Replaceable-Core Filter Dryers: Comply with AHRI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 microns, pleated with integral end rings; stainless-steel support.
 - a. Must be capable of being replaced with activated charcoal Desiccant Media.
3. End Connections: Socket.
4. Access Ports: Connections at entering and leaving sides for pressure differential measurement.
5. Maximum Pressure Loss: 1 PSIG
6. Rated Flow: Selected to exceed tonnage of each system
7. Maximum Rated Pressure: 650 PSIG

C. Liquid Line "Catch-All" Filter Drier

1. Body: Epoxy coated-steel shell
2. Designed for reverse flow (for heat-pump applications).
3. End Connections: Socket.
4. Maximum Pressure Loss: 1 PSIG
5. Rated Flow: Selected to exceed tonnage of each system
6. Maximum Rated Pressure: 650 PSIG

PART 3 - EXECUTION

3.1 PRODUCT STORAGE AND HANDLING

- A. Reject all pipe and fittings that show evidence of scale, slag, dirt, and debris from inside or outside of pipe and fittings.
- B. Store piping on site off ground and with manufacturer end caps in place until time of installation.
 1. Piping deemed to be stored improperly shall be removed from site and replaced.

3.2 PIPING APPLICATIONS

- A. Refrigerant Lines 7/8" and Smaller:
 1. Copper, Type ACR, annealed-temper tubing and wrought-copper fittings
 - a. Brazed joints. Flared joints are acceptable at indoor unit connections only.
 - b. Piping must be level, straight, and without sags.
 2. Copper, Type ACR, drawn-temper tubing and wrought-copper fittings

- a. Brazed joints.
- B. Refrigerant Lines 1" and Larger:
 - 1. Copper, Type ACR, drawn-temper tubing and wrought-copper fittings
 - a. Brazed joints.

3.3 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valve in liquid, hot gas, and suction line at each outdoor unit frame with Schrader port oriented towards outdoor unit access.
- B. Bypass filter assembly
 - 1. Locations: Install in suction line and liquid line between outdoor unit and building piping system.
 - a. Suction: Replaceable core filter assembly
 - b. Liquid: Filter -Drier assembly
 - 2. Install a full-size, three-valve bypass filter assembly.
 - a. At startup, and as required, valve refrigerant to flow through the filter assembly with filter media installed.
 - b. After two (2) weeks of continuous operation after startup, valve refrigerant to bypass the filter assembly. Contractor shall evacuate and weigh refrigerant in bypass and remove replaceable core filter media. At the time of removal, the VRF manufacturer's representative shall inspect filter with the contractor on site. Upon manufacturer's representative's acceptance, contractor shall leave filter media removed and shall evacuate bypass suction assembly to under 500 microns, break vacuum with R-410A refrigerant, and charge bypass so standing pressure is equal to that of main piping. If filter cleanliness is not accepted by the manufacturer's representative, the process shall be repeated, at a time interval dictated by the representative, until acceptance at no cost to the Owner.
- C. Install service valve on each line at each heat recovery box, on the outdoor unit side (upstream) of box, with Schrader port on box side (downstream) of valve.
- D. Outdoor unit refrigerant piping connections (multi-chassis systems)
 - 1. Main pipe segments shall be mounted at a height less than the outdoor unit connection.
 - 2. Install inverted trap on the low pressure vapor and the high pressure vapor pipe between each outdoor unit chassis and outdoor unit interconnecting pipe wye branch, within 6" of wye. Inverted traps must be a minimum of 6" high and the same diameter as the interconnecting pipe. Liquid interconnecting pipe does not need traps.

3.4 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved in Submittals.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install refrigerant piping plumb/level.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Install piping adjacent to machines to allow service and maintenance.
- H. Install piping free of sags and bends.
- I. Use fittings for changes in direction and branch connections. All wye fittings and headers are to be installed plumb/level either horizontal or vertical and be supported.
- J. Oil Traps
 - 1. No oil traps shall be installed in piping system, except where approved by VRF equipment manufacturer.
 - 2. Oil traps shall be installed at the outdoor unit frame where required by unit manufacturer.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings per the approved shop drawings.
- M. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- N. Piping expansion shall be taken into account and where required, expansion loops shall be installed per manufacturer's installation documentation. Piping supports shall allow piping and insulation to move freely to accommodate expansion and contraction.
- O. When brazing, remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near valve core. Protect isolation valves from heat damage by wrapping valve with wet rag while brazing.

- P. Install saddle or other means at piping supports to allow the pipe and insulation to move linearly in the support.
- Q. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- R. Identify refrigerant piping and valves according to Section "Identification for HVAC Piping and Equipment."
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section "Sleeves and Sleeve Seals for HVAC Piping."
- T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section "Sleeves and Sleeve Seals for HVAC Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section "Escutcheons for HVAC Piping."

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Brazing
 - 1. Pipe and fittings shall be continuously purged with dry nitrogen during brazing to prevent scale formation.
 - 2. Brazing shall not begin until complete nitrogen flow is verified via oxygen sensor reading at purge outlet, located immediately downstream of brazing site, confirms all oxygen has been displaced with nitrogen.
 - 3. Nitrogen purge shall continue until brazing is complete and pipe is cool to the touch.
- C. Brazed Joints: Construct joints according to AWS's "Brazing Handbook,"
- D. Flares
 - 1. Make flare connections per VRF equipment manufacturer's instructions.
 - 2. Use torque wrench, with backup wrench, to tighten flares per VRF equipment manufacturer's instructions.

3.6 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for seismic restraints in Section "Vibration and Seismic Controls for HVAC."
- B. Comply with Section "Hangers and Supports for HVAC Piping and Equipment" for hangers, supports, and anchor devices.

- C. Install hangers for copper tubing with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Support horizontal piping within 12 inches of each fitting.
- E. Support vertical runs of copper tubing to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.7 FIELD QUALITY CONTROL

- A. VRF equipment manufacturer's representative piping inspections
 - 1. The VRF equipment manufacturer's representative shall perform a minimum of two (2) site visits per system during construction, separate from the commissioning process, for field verification of proper system/piping installation for each system.
 - 2. A formal report shall be forwarded electronically to the Mechanical Contractor and General Contractor for dissemination to all parties after each visit.
 - 3. Each report shall indicate which area(s) were inspected, the deficiencies found (with photograph documentation), the required corrective action conveyed to which personnel with the mechanical contractor, which previously identified deficiencies have been corrected, and which are outstanding.
 - 4. Deficiency items inspected for shall include, but not be limited to, manufacturer-specific pipe length/routing rules, the presence of improper oil traps, the use of dry nitrogen purge during brazing, proper flaring techniques, adequate piping supports to avoid sagging, adequate piping insulation, proper communication wiring installation, expansion/contraction control, etc.
- B. Destructive testing inspection of the refrigerant pipe system
 - 1. The contractor shall include in his bid the cost to replace 5% of all brazed joints/fittings, per the below stipulations.
 - 2. At any time during the construction process, including and up to the day of commissioning, the owner's quality control inspector, or the VRF equipment manufacturer's representative, shall have the right to select any brazed joint/fitting in the piping system to be cut out for inspection. Removal of joint/fitting shall be by the contractor.
 - 3. If at any time in the destructive testing process, evidence is found that a braze was conducted without the oxygen being first dissipated and removed from the pipe via dry-nitrogen purge, that piping system shall be removed and replaced at no cost to the Owner.
 - 4. All necessary piping rework shall not delay the construction schedule.
 - 5. A report including pictures of the inside of the pipe/fitting/braze shall be made by the quality control inspector/VRF equipment manufacturer's representative. A copy of the report for each destructive test shall be sent to the Mechanical Contractor and General Contractor for dissemination to all parties.
- C. System pressure test

1. Test for leaks in the piping system and VRF indoor units by pressurizing the system with dry nitrogen. All isolation valves shall be open during test, however VRF outdoor units shall be isolated.
2. Pressurize system to 150 PSIG.
3. If 150 PSIG is maintained for 5 minutes, increase pressure to 300 PSIG.
4. If 300 PSIG is maintained for 15 minutes, increase pressure to 550 PSIG.
5. If 550 PSIG pressure is maintained for 24 hours, the system passes pressure test.
6. At any point during test, if pressure is not maintained for specified time period, find and repair leaks and begin pressure test again.
7. If the ambient temperature changes during the specified testing period, adjust results by 0.79 PSIG for each 1°F of temperature difference.
8. This procedure shall meet the minimum requirements for system pressure test. Manufacturer specific requirements, where more stringent, shall govern.

D. System vacuum test

1. Test for leaks in the piping system and VRF indoor units by utilizing the triple evacuation process described below. All isolation valves shall be open during test, however VRF outdoor units shall be isolated.
2. Install core in filter dryers.
3. Evacuate the system to lowest micron level possible.
4. Break vacuum with 50 PSIG dry nitrogen for appropriate amount of time to "sweep" moisture from piping.
5. Vent nitrogen down to 1-3 PSIG.
6. Evacuate to lowest micron level possible.
7. Break vacuum with 50 PSIG dry nitrogen for appropriate amount of time to "sweep" moisture from piping.
8. Vent nitrogen down to 1-3 PSIG.
9. Evacuate to static level of less than 500 micron.
10. Vacuum level must remain less than 500 micron for 24 hours with vacuum pump off and isolated from the system.
11. If vacuum is not maintained for specified time period, find and repair leaks and begin vacuum test again.
12. This procedure shall meet the minimum requirements for system vacuum test. Manufacturer specific requirements, where more stringent, shall govern.

E. System performance verification

1. After the system(s) are turned over to the Owner as complete and fully functioning, the VRF equipment manufacturer's representative shall perform a 3-month, 6-month, and 12-month system performance verification via manufacturer-specific service/commissioning software. A report/letter conveying findings shall be submitted to the Mechanical Contractor, General Contractor, and Owner. Should any items of concern be found during the process, the Mechanical Contractor shall fully investigate and repair any issues at no cost to the Owner. In that event, the system performance verification shall be repeat at 3-months and 6-months, until the system(s) are deemed free of issues.

END OF SECTION 232301

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SECTION 232513 - WATER TREATMENT FOR CLOSED LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following HVAC water-treatment systems:

1. Bypass chemical-feed equipment and controls.
2. Biocide chemical-feed equipment and controls.
3. Chemical treatment test equipment.
4. HVAC water-treatment chemicals.

1.3 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems shall include rust and corrosion inhibitors and have the following water qualities:
 1. Glycol Percentage by Volume: 0%
 2. pH: Maintain a value within 9.0 to 10.5
 3. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
 4. Boron: Maintain a value within 100 to 200 ppm.
 5. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
 6. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 7. TDS: Maintain a maximum value of 10 ppm.
 8. Ammonia: Maintain a maximum value of 20 ppm.
 9. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
 10. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
 - c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.

- d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
- e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
 - 1. Bypass feeders.
- B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.
 - 1. Include diagrams for power, signal, and control wiring.
- C. Water-Treatment Program: Written water treatment plan including chemical types and estimated quantities required to achieve water quality defined in the "Performance Requirements" Article above.
- D. Water Analysis: Illustrate water quality available at Project site.
- E. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.

1.5 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.6 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
 - 1. Initial water analysis and HVAC water-treatment recommendations.
 - 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 - 3. Periodic field service and consultation.
 - 4. Customer report charts and log sheets.
 - 5. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
 - 1. Capacity: 5 gal. (19 L).
 - 2. Minimum Working Pressure: 125 psig (860 kPa).

2.3 CHEMICAL TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
- B. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
 - 1. Two-station rack for closed-loop systems.
 - 2. Four -station rack for open systems.

2.4 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 CHEMICAL TREATMENT FOR CLOSED LOOP PIPING SYSTEMS

- A. After flushing and cleaning the piping systems per specification section 232113, 3.8, flush and refill with clean water until all traces of residual detergent and suspended matter are gone.

3.3 INSTALLATION

- A. Install chemical application equipment level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible.
- B. Install water testing equipment on wall near water chemical application equipment.
- C. Bypass Feeders: Install in closed hydronic systems and equipped with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
 - 2. Install water meter in makeup water supply.
 - 3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
 - 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
 - 5. Install a swing check on inlet after the isolation valve.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in other sections of the specifications.
- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet.

3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.

3. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 4. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 5. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 6. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 7. Repair leaks and defects with new materials and retest piping until no leaks exist.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Comply with ASTM D 3370 and with the following standards:
1. Silica: ASTM D 859.
 2. Acidity and Alkalinity: ASTM D 1067.
 3. Iron: ASTM D 1068.
 4. Water Hardness: ASTM D 1126.

END OF SECTION 232500

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SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Rectangular ducts and fittings.
 - 2. Round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: The contractor shall submit duct layout 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. Duct installation, indicating coordination with general construction, building components including structure, hydronic, plumbing, and sprinkler piping, electrical conduits, and other building services. Indicate proposed duct sizes, elevations, changes in elevation, etc.
 - 2. Suspended ceiling components.
 - 3. Suspended mechanical equipment including required clearances.
 - 4. Size and location of access to concealed equipment.
 - 5. Penetrations of smoke barriers and fire-rated construction.

- B. RFI's related to coordination items will not be reviewed unless coordination drawings have been submitted.

1.5 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 EXPOSED DUCTWORK

- A. All exposed ducts in normally occupied spaces shall have a paint grip surface.

2.2 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger Than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
 - 2. Round ducts exposed to view shall have spiral lock seams only. Longitudinal snap lock seams are not allowed for exposed duct.
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- E. Round ducts exposed to view shall have spiral lock seams only. Longitudinal snap lock seams are not allowed for exposed duct.

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials 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. Finished for Surfaces Galvanized Coating Designation: G60 (Z180).
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- G. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 - 2. Tape Width: 3 inches (76 mm).
 - 3. Sealant: Modified styrene acrylic.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
 - 7. Service: Indoor and outdoor.
 - 8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 - 10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. VOC: Maximum 75 g/L (less water).
 - 7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.

8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
10. Equal to Foster 32-19 and Childers CP-146.

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 shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant 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. 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 (0.14 L/s per sq. m) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install balancing dampers in all duct branches to grilles, registers, and diffusers. Install as close as possible to branch duct takeoff from larger ducts. Dampers in air distribution devices shall not be used to balance systems.
- D. Install round ducts in maximum practical lengths.
- E. Install ducts with fewest possible joints.
- F. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- G. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- H. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
- J. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- K. Where ducts pass through non-fire-rated interior partitions and exterior walls whether exposed to view or concealed, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Flanges to have a mill phosphatized finish for painting. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
- L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers.

- M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. All exposed ducts in normally occupied spaces shall have a paint grip surface.
- B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- C. Round ducts exposed to view shall have spiral lock seams only. Longitudinal snap lock seams are not allowed for exposed duct.
- D. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- E. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- F. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- G. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class A.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class A.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 7. Unconditioned Space, Exhaust Ducts: Seal Class C.
 - 8. Unconditioned Space, Return-Air Ducts: Seal Class A.
 - 9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
 - 10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
 - 11. Conditioned Space, Exhaust Ducts: Seal Class B.
 - 12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "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 (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.
- D. Hangers Exposed to View: Wire rope hanger and clutcher equal to Ductmate. Install with wire clutcher as close as possible to top of duct.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors.
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 DUCT CLEANLINESS

- A. Mechanical equipment including air handlers, rooftop package units, etc. and all ducts and air distribution devices shall be sealed to maintain clean, dust and debris free interiors and are to remain sealed until building construction is complete. When used during construction all supply, return, and transfer ducts shall have filter media installed in all inlets and outlets for protection from construction dust. The architect, engineer, general contractor, construction manager, and/or owner may inspect duct and air distribution devices at any time. If ducts and

air distribution devices are found to contain contaminants, the entire duct system will be required to be cleaned per the description below before testing, adjusting, and balancing.

- B. Ducts and air distribution devices not maintained clean and debris free per the description above, and found to contain contaminants are to be cleaned prior to testing, adjusting, and balancing per the following:

1. Use service openings for entry and inspection.
 - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer.
 - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - c. Remove and reinstall ceiling to gain access during the cleaning process.
2. Particulate Collection and Odor Control:
 - a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
 - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
3. Clean the following components by removing surface contaminants and deposits:
 - a. Air outlets and inlets (registers, grilles, and diffusers).
 - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
 - d. Coils and related components.
 - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - f. Supply-air ducts, dampers, actuators, and turning vanes.
 - g. Dedicated exhaust and ventilation components and makeup air systems.
4. Mechanical Cleaning Methodology:
 - a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
 - b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
 - c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
 - d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.

- e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
- f. Provide drainage and cleanup for wash-down procedures.
- g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.7 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive 2-inch wg.
- b. SMACNA Leakage Class for Rectangular: 12.
- c. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Constant-Volume Air-Handling Units:

- a. Pressure Class: Positive 3-inch wg.
- b. SMACNA Leakage Class for Rectangular: 6.
- c. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

- a. Pressure Class: Positive 3-inch wg.
- b. SMACNA Leakage Class for Rectangular: 6.
- c. SMACNA Leakage Class for Round and Flat Oval: 6.

4. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive 3-inch wg.
- b. SMACNA Leakage Class for Rectangular: 6.
- c. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive or negative 2-inch wg.
- b. SMACNA Leakage Class for Rectangular: 12.
- c. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

- a. Pressure Class: Positive or negative 3-inch wg.

- b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 - 3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
- D. Exhaust Ducts:
 - 1. Ducts Connected to Fans Exhausting Air:
 - a. Pressure Class: Negative 2-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 12.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 - 2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. SMACNA Leakage Class for Rectangular: 6.
 - c. SMACNA Leakage Class for Round and Flat Oval: 6.
 - 3. Exhaust Ducts Connected to Dust Collection Systems:
 - a. Mechanical contractor shall gauge ductwork per SMACNA industrial construction
 - b. standards. Hanging of the ductwork shall comply to both the SMACNA industrial
 - c. standard and SMACNA HVAC standard. Gripple type hangers are approved for use.
 - d. Ductwork specifications:
 - 1) Fume extraction and exhaust ductwork - galvanized spiral ductwork shall be provided per SMACNA class 1, material class 26, and 10" w.g. neg pressure.
 - 2) Only spiral ductwork shall be permitted to be used.
 - 3) Filtered supply ductwork shall be gauged per standard SMACNA HVAC standards and sized for .08 - .10" of pressure loss per 100 feet of linear equivalent ductwork.
 - 4) Ductwork may be joined with gasketed fittings (as preferred method). Slip fit fittings and sheet metal screws may be used. Use of external mastic or duct tape shall be minimal and not used to cover over errors or omissions in installation.
 - 4. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive or negative 2-inch wg.
- b. SMACNA Leakage Class for Rectangular: 12.
- c. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units:

- a. Pressure Class: Positive or negative 3-inch wg.
- b. SMACNA Leakage Class for Rectangular: 6.
- c. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 3-inch wg.
- b. SMACNA Leakage Class for Rectangular: 3.
- c. SMACNA Leakage Class for Round and Flat Oval: 3.

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts:

- a. Exposed to Airstream: Match duct material.
- b. Not Exposed to Airstream: Match duct material.

3. Aluminum Ducts: Aluminum.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a. Velocity 1000 fpm (5 m/s) or Lower:

- 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
- 2) Mitered Type RE 4 without vanes.

b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

- 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
- 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
- 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

c. Velocity 1500 fpm (7.6 m/s) or Higher:

- 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
 - c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Ducts designed to operate at a Pressure Class Higher Than **3-Inch wg**: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Testing of each duct section is to be performed with access doors, coils, filters, dampers, and other duct-mounted devices in place as designed. No devices are to be removed or blanked off so as to reduce or prevent additional leakage.
 - 5. Test for leaks before applying external insulation.
 - 6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 7. Give days' advance notice for testing.
 - 8. The construction manager/general contractor shall witness and document the testing and results.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Backdraft and pressure relief dampers.
 - 2. Manual volume dampers.
 - 3. Control/Motorized dampers.
 - 4. Fire dampers.
 - 5. Flange connectors.
 - 6. Turning vanes.
 - 7. Duct-mounted access doors.
 - 8. Flexible connectors.
 - 9. Flexible ducts.
 - 10. Duct accessory hardware.
 - 11. Duct silencers.
 - 12. Louvers

1.3 ACTION SUBMITTALS

- A. Product Data: For each backdraft, pressure relief damper, control damper (including actuator), fire damper, smoke damper (including actuator), flexible duct, flexible duct connector, and combination fire/smoke damper (including actuator) to be used on the project.
- B. Shop Drawings: For each backdraft, pressure relief damper, control damper, fire damper, smoke damper, flexible duct, flexible duct connector, and combination fire/smoke damper to be used on the project. Include plans, elevations, sections, details and attachments to other work.
 - 1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Control-damper installations.
 - b. Fire-damper and smoke-damper installations, including sleeves; and duct-mounted access doors.
 - c. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Description: Gravity balanced.
- B. Maximum Air Velocity: 2000 fpm.
- C. Maximum System Pressure: 3-inch wg (0.8 kPa).
- D. Frame: Hat-shaped, 0.05-inch- (1.3-mm-) thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
- E. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch (150-mm) width, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum with sealed edges.
- F. Blade Action: Parallel.

- G. Blade Seals: Felt.
- H. Blade Axles:
 - 1. Material: Nonferrous metal.
 - 2. Diameter: 0.20 inch (5 mm).
- I. Tie Bars and Brackets: Aluminum.
- J. Return Spring: Adjustable tension.
- K. Bearings: Steel ball or synthetic pivot bushings.
- L. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Electric actuators.
 - 4. Chain pulls.
 - 5. Screen Mounting: Front mounted in sleeve.
 - a. Sleeve Thickness: 20 gage (1.0 mm) minimum.
 - b. Sleeve Length: 6 inches (152 mm) minimum.
 - 6. Screen Mounting: Rear mounted.
 - 7. Screen Material: Galvanized steel.
 - 8. Screen Type: Bird for exhaust systems, Insect for intake systems.
 - 9. 90-degree stops.

2.4 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Standard leakage rating, with linkage outside airstream.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames:
 - a. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch (1.62 mm) thick.
 - 5. Blade Axles: Galvanized steel.

6. Bearings:
 - a. Oil-impregnated bronze.
 - b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

7. Tie Bars and Brackets: Galvanized steel.

B. Jackshaft:

1. Size: 0.5-inch (13-mm) diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

C. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.5 CONTROL/MOTORIZED DAMPERS

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

1. Cesco Products; a division of Mestek, Inc.
2. Greenheck Fan Corporation.
3. Lloyd Industries, Inc.
4. McGill AirFlow LLC.
5. Metal Form Manufacturing, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Young Regulator Company.

B. Frames:

1. Hat shaped.
2. Minimum 16 ga. thick, galvanized sheet steel
3. Mitered and welded corners.

C. Blades:

1. Multiple blade with maximum blade width of 6 inches (152 mm).

2. Parallel-blade design.
 3. Galvanized-steel.
 4. 0.064 inch (1.62 mm) thick single skin.
 5. Blade Edging: Closed-cell neoprene.
 6. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
- D. Blade Axles: 1/2-inch- (13-mm-) diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
- E. Bearings:
1. Oil-impregnated bronze.
 2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
 3. Thrust bearings at each end of every blade.
- F. Actuator Electrical Connection: 24 V

2.6 FIRE DAMPERS

- A. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000-fpm velocity.
- C. Fire Rating: 1-1/2 and 3 hours.
- D. Frame: Curtain type with blades outside airstream fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
1. Minimum Thickness: 0.05 inch thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.024-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.7 FLANGE CONNECTORS

- A. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- B. Material: Galvanized steel.
- C. Gage and Shape: Match connecting ductwork.

2.8 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.
- B. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- C. Vane Construction: Double wall.

2.9 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.10 DUCT ACCESS PANEL ASSEMBLIES

- A. Labeled according to UL 1978 by an NRTL.
- B. Panel and Frame: Minimum thickness 0.0528-inch (1.3-mm) carbon steel.
- C. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).
- E. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.11 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.
- D. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
 - 2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
 - 2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
 - 3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

2.12 FLEXIBLE DUCTS

- A. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
 - 1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
 - 2. Maximum Air Velocity: 4000 fpm (20 m/s).
 - 3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).

- B. 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 vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

- C. Flexible Duct Connectors:

1. Clamps: Nylon strap in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
2. Non-Clamp Connectors: Tape, plus sheet metal screws.

2.13 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.

2.14 LOUVERS

- A. Materials:

1. Galvanized-Steel Sheet: ASTM A 653/A 653M, G60 (Z180) zinc coating, mill phosphatized.
2. Fasteners: Of same basic metal and alloy as fastened metal or 300 series stainless steel, unless otherwise indicated. Do not use metals that are corrosive or incompatible with joined materials.
 - a. Use types and sizes to suit unit installation conditions.
 - b. Use Phillips flat-head screws for exposed fasteners, unless otherwise indicated.
3. Anchors and Inserts: Of type, size, and material required for type of loading and installation indicated. Use nonferrous metal or hot-dip galvanized anchors and inserts for exterior installations and elsewhere as required for corrosion resistance. Use toothed steel or expansion bolt devices for drilled-in-place anchors.
4. Bituminous Paint: Cold-applied asphalt mastic complying with SSPC-Paint 12 except containing no asbestos fibers.

- B. Fabrication, General:

1. General: Fabricate louvers and vents to comply with requirements indicated for design, dimensions, materials, joinery, and performance.

2. Assemble louvers in shop to minimize field splicing and assembly. Disassemble units as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation.
3. Maintain equal louver blade spacing, including separation between blades and frames at head and sill, to produce uniform appearance.
4. Fabricate frames, including integral sills, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances of louvers, adjoining construction, and perimeter sealant joints.
5. Include supports, anchorages, and accessories required for complete assembly.
6. Provide louver units in continuous vertical assemblies without horizontal joints in sizes illustrated.
7. Provide sill extensions and loose sills made of same material as louvers where indicated or required for drainage to exterior and to prevent water penetrating to interior.
8. Join frame members to one another and to fixed louver blades by concealed from view connections as standard with louver manufacturer.

C. Fixed, Extruded-Aluminum Wall Louvers:

1. Drainable, stationary, Fixed-Blade Louvers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," 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. Unless otherwise indicated on the plans, install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan and at outside air intakes as close as possible to the exterior.
- E. Install volume dampers at all points on supply, return, and exhaust systems where branches extend from larger ducts to diffusers, register, grilles or other termination points. Install as close as possible to the take off from the larger duct. Install the damper arm on the side or bottom of duct. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 1. Install steel volume dampers in steel ducts.
 2. Install aluminum volume dampers in aluminum ducts.
- F. Set dampers to fully open position before testing, adjusting, and balancing.

- G. Install test holes at fan inlets and outlets and elsewhere as indicated.
- H. Install fire dampers according to UL listing.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-foot (15-m) spacing.
 - 8. Upstream and downstream from turning vanes in ducts larger than 14" on one side.
 - 9. Upstream or downstream from duct silencers.
 - 10. Control devices requiring inspection.
 - 11. Elsewhere as indicated.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
 - 2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
 - 3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
 - 4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
 - 5. Body Access: 25 by 14 inches (635 by 355 mm).
 - 6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).
- L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
- N. Connect flexible ducts to metal ducts with draw bands, plus sheet metal screws.
- O. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.
 - 2. Inspect locations of access doors and verify that purpose of access door can be performed.

3. Operate fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.

END OF SECTION 233300

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SECTION 233416 - CENTRIFUGAL HVAC FANS

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. Utility set fans.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Unusual Service Conditions

1. Base fan-performance ratings on the following:

- a. 500 deg F for 4 hours
- b. 1000 deg F for 2 hours

2. Fans shall be direct drive.

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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

2.2 UTILITY SET FANS

A. General:

1. Base fan performance at standard conditions (density 0.075 Lb/ft³).
2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
3. Each fan shall be direct drive.
4. Each fan shall bear a permanently affixed manufacture's engraved metal nameplate containing the model and individual serial number.
5. Fans are to be equipped with lifting lugs.
6. Constructed of heavy gauge steel
7. After fabrication, untreated steel components go through a multi-stage cleaning and pre-treatment process before being finished with a high-performance powder coating having a minimum thickness of 2-4 mils, electrostatically applied and baked. Finish color shall be RAL-7023, concrete grey. Coating must exceed 1,000-hour salt spray under ASTM B117 test method. No uncoated metal fan parts will be allowed.

B. Fan Housing and Outlet:

1. Fan housing is to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
2. Fan shall be of airtight construction with the scroll panel material formed and embedded into the side panels [continuously welded heavy gauge scroll construction]. All interior and exterior surface untreated steel shall be coated with a high-performance powder coating.
3. Housing and bearing support shall be constructed of bolted framework. [welded formed steel members to prevent vibration and rigidly support the shaft and bearings].

4. An OSHA compliant shaft guard shall be included to completely cover the shaft for arrangement 8 only.
- C. Fan Wheel:
1. The fan wheel shall be of the single width backward inclined centrifugal type.
 2. Fan Wheel shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
 3. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
- D. Fan Motors and Drive:
1. AC induction motor type
 - a. Motors shall meet or exceed EISA (Energy Independence and Security Act) efficiencies. Motors to be NEMA T-frame, 690, 870, 1170, 1770 or 3500 RPM in 60 Hz, (720, 950, 1425 or 2900 in 50 Hz) Open Drip Proof (ODP) or Totally Enclosed Fan Cooled (TEFC).
- E. Accessories and options: As indicated in the equipment schedules on the plans

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install centrifugal fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration-isolation devices.
- E. Install units with clearances for service and maintenance.
- F. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to fans to allow service and maintenance.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 STARTUP SERVICE:

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 10. Shut unit down and reconnect automatic temperature-control operators.
 - 11. Remove and replace malfunctioning units and retest as specified above.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing and after completing startup service, clean fans internally to remove foreign material and construction dirt and dust.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Fans and components will be considered defective if they do not pass tests and inspections.
- B. Prepare test and inspection reports.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

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SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Centrifugal roof ventilators.
 - 2. Ceiling-mounted ventilators.
 - 3. Square in-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
- B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
 - 8. Wiring Diagrams: For power, signal, and control wiring.
 - 9. Accessories

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set(s) for each belt-driven unit.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.8 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

- A. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 - 1. Accurex
 - 2. Acme
 - 3. Aerovent
 - 4. Broan-NuTone LLC.
 - 5. Carnes Company.

6. Greenheck Fan Corporation.
7. Loren Cook Company.
8. PennBarry.
9. Twin City Fan & Blower

2.2 CENTRIFUGAL ROOF VENTILATORS

- A. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
- B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- C. Belt Drives (where indicated):
 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.
 5. Fan and motor isolated from exhaust airstream.
- D. Direct Drives (where indicated):
 1. Motor shall be an electronically commutated motor rated for continuous duty and furnished with internally mounted potentiometer speed controller unless scheduled otherwise on the plans.
- E. Kitchen hood ventilators
 1. UL 762 Listed
 2. High Heat operation 300 °F
 3. Abnormal flare up tested
- F. Accessories: As indicated on the equipment schedules on the plans.
- G. Capacities and Characteristics: As indicated on the equipment schedules on the plans.

2.3 CEILING-MOUNTED VENTILATORS

- A. Housing: Steel, lined with acoustical insulation.
- B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- C. Grille: Plastic or Painted aluminum as indicated on the equipment schedule, louvered grille with flange on intake and thumbscrew attachment to fan housing.
- D. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

- E. Accessories: As indicated on the equipment schedules on the plans.
- F. Capacities and Characteristics: As indicated on the equipment schedules on the plans.

2.4 SQUARE IN-LINE CENTRIFUGAL FANS

- A. Description: Square in-line centrifugal fans.
- B. Housing:
 - 1. Housing Material: Reinforced steel.
 - 2. Housing Construction: Side panels shall be easily removable for service. Include inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosures around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum airfoil blades welded to aluminum hub.
- F. Motor Enclosure: Open, dripproof.
- G. Accessories:
 - 1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
 - 2. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 3. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 4. Companion Flanges: For inlet and outlet duct connections.
 - 5. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 - 6. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 - 7. Side Discharge: Flange connector and attachment hardware to provide right-angle discharge on side of unit.

2.5 MOTORS

- A. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." 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, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install power ventilators level and plumb.
- C. Support units using elastomeric mounts or spring isolators having a static deflection of 1 inch as indicated on the equipment schedules.
- D. Secure roof-mounted fans to roof curbs with cadmium-plated hardware.
- E. Ceiling Units: Suspend units from structure; use steel wire or metal straps and spring isolators.
- F. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch.
- G. Install units with clearances for service and maintenance.
- H. Label units according to requirements specified in other sections of the specifications.

3.2 CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Install ducts adjacent to power ventilators to allow service and maintenance.
- B. Ground equipment according to Division 26.
- C. Connect wiring according to Division 26.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. 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.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire 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.

3.4 TESTING, ADJUSTING AND BALANCING

- A. Testing, adjusting and balancing of the mechanical systems and related ancillary equipment will be performed by a qualified TAB Firm. The preparation for and corrections necessary for the testing, adjusting and balancing of these systems are the responsibility of the Mechanical Contractor.
- B. The Mechanical Contractor shall make any changes or replacements to the sheaves, belts, dampers and valves required for correct balance as advised by the TAB Firm. Any changes shall keep the duct system within its design limitations with respect to the speed of the device and pressure classification of the distribution system. Material and labor costs for sheave changes are to be provided at no additional costs.
- C. Adjust damper linkages for proper damper operation.
- D. Adjust belt tension.
- E. Lubricate bearings.

METROPOLITAN CC LONGVIEW AUTOMOTIVE INSTITUTE
METROPOLITAN COMMUNITY COLLEGE
LEE'S SUMMIT, MO

13-23128-00
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END OF SECTION 233423

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SECTION 233439 - HIGH-VOLUME, LOW-SPEED FANS

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 high-volume, low-speed fans.

1.3 DEFINITIONS

- A. HVLS - High volume, low speed.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Show dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For each HVLS fan.
 - 1. Include design calculations and details for selecting product mounting components and restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.
- B. Restraint Details:
 - 1. Design Analysis: To support selection and arrangement of 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.

- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

- a. Blades - Lifetime (Parts)
- b. Hub - Lifetime (Parts)
- c. Motor - 5 years (Parts)
- d. Controller - 1 year (Parts).

2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Listed and labeled to UL 507.
- C. Comply with NFPA 13 requirements for HVLS fans.
- D. AMCA Compliance:
 1. Test HVLS fans according to AMCA 230.
 2. Certify HVLS fan performance according to AMCA 211.
- E. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.

2.2 MANUFACTURERS

- A. Source Limitations: Obtain all HVLS fans from a single manufacturer.

2.3 HIGH-VOLUME, LOW-SPEED FANS

- A. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with variable-speed motor controller.
 - 1. Provide fan designed to circulate large air volume, vertically, at low velocity.
 - 2. Maximum Operating Temperature: 140 (60) deg F (deg C).
- B. Complete Unit: The fan shall be designed to move an effective amount of air for cooling and destratification in large industrial/commercial applications over an extended life. The fan and components shall be designed specifically for high volume, low speed fans to ensure lower noise operation. The sound levels from the fan operating at maximum speed shall not exceed 35 dBA (measured 20' or 6.1 m below the blades and 20' or 6.1 m horizontally from the center of the fan).
- C. Blades: The fan shall be equipped with six (6) high volume, low speed blades of precision 6005-T5 extruded aluminum alloy. Each blade shall be of the high performance STOL (Short Take-Off and Landing) design. The blades shall be connected by means of two (2) locking bolts per blade. The blades shall be connected to "H-Strut" which is connected to the hub and interlocked with two sets of six stainless steel retainers.
- D. Wingtips: The fan shall be equipped with six (6) wingtips designed to redirect outward airflow into downward airflow, thereby enhancing the efficiency and effectiveness of the fan. The wingtips shall be molded of Nylon 66. The wingtips shall be attached at the tip of each blade by means of a single screw. The color of the wingtips shall be "SkyBlade Red"
- E. Motor: The fan motor shall be an ECM (Electronically Commutated Motor), BLDC (Brushless DC), gearless direct drive 115V 1 Ph, 230V 1-3 Ph, and 460V 3 Ph. The motor shall be totally enclosed with an IP65 NEMA classification. The motor shall be manufactured with Class F insulation. The output shaft of the motor shall be no less than a 3" keyless shaft with bearings that are lubed for life.
- F. Extension Bar: The fan shall be equipped with an extension bar that provides a structural connection between the fan assembly and upper mounting system. The extension bar shall be steel 2" x 2" (5.08 cm x 5.08 cm) square tubing and powder-coated for corrosion resistance and appearance. Standard length of extension bar is 1-Ft. available in 1-Ft. increments up to 10-Ft. as specified by the architect or owner.
- G. Hub: The fan hub shall be minimum 1/4" steel for high strength and rigidity. The hub shall be secured to the output shaft of the motor by means of a precision cut steel cylinder & interlocking bushing system. Both hub and steel bushing shall be precision machined to achieve a factory balanced and solid rotating assembly. The hub shall incorporate six (6) safety retaining brackets no less than 1/8" made of stainless steel that shall restrain the hub/blade assembly in case of motor output shaft failure.

- H. Mounting System: The fan mounting system shall be designed for quick and secure installation from a structural support beam. All components in the mounting system shall be of welded construction using 1/4" powder-coated steel. All mounting bolts shall be Grade 5 or Grade 8 SAE.
- I. Guy Wire: The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure. The safety cable shall be a four point restraint 1/8" (0.32 cm) diameter and fabricated out of 7 x 7 stranded galvanized steel with each cable having a breaking strength of 1,000 lbs. The cable is to be secured with supplied wire rope clips or fasteners. Field construction of safety cables is not permitted.
- J. Safety Cable: The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure. The safety cable shall be 1/8" (0.32 cm) diameter and fabricated out of 7 x 7 stranded galvanized steel a break strength of 1,000 lbs. The cable is to be secured with supplied wire rope clips or fasteners. Field construction of safety cables is not permitted.
- K. VFD Enclosure: The fan controller shall be constructed using a Variable Frequency Drive (VFD) that is pre-assembled and factory programmed to communicate a 60 second ramp up/down to the fan, to minimize the starting and braking torques and for smooth and efficient operation. The VFD enclosure shall be pre-assembled and internally wired for ease of installation. The controller shall be onboard with IP65 rating.
- L. Controls: Provide wall-mounted control for BACnet & BMS integration. Control shall be capable of controlling multiple fans in groups or individually.

PART 3 - EXECUTION

3.1 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.
- B. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.
- C. Install fan according to manufacturer's published instructions.
- D. Comply with NECA 1 and NFPA 70.
- E. Comply with NFPA 13 for installation of HVLS fans and maximum allowable fan diameter. Center HVLS fans between four adjacent sprinklers. Minimum vertical clearance from HVLS fan to sprinkler deflector is 3 feet (0.9 m).
- F. Comply with NFPA 72 and interlock HVLS fans to shut down upon receiving an alarm from fire alarm system.
- G. Equipment Mounting:

1. Anchor fan to building structure with manufacturer's recommended mounting bracket for installed condition.
2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
5. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."

H. Install unit to permit access for maintenance.

I. Install parts and accessories shipped loose.

J. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
3. Verify proper motor rotation direction and free fan rotation.
4. Check bearing lubrication.

3.2 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
- E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.3 CONTROL CONNECTIONS

- A. Connect control wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

- C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.
- D. Install control devices furnished by manufacturer, but not factory mounted.
- E. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
- F. Protect installed units from damage caused by other work.

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Fan or components will be considered defective if fan or components do not pass tests and inspections.
- C. Prepare and submit test and inspection reports.

3.5 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.6 CLEANING

- A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain HVLS fans.

END OF SECTION 233439

SECTION 233600 - AIR TERMINAL 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. Shutoff, single-duct air terminal units.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.
 - 1. Air terminal units.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. Include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.5 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Anemostat Products; a Mestek Company.
 2. Carnes.
 3. Krueger.
 4. Nailor Industries Inc.
 5. Price Industries.
 6. Titus.
 7. Trane; a business of American Standard Companies
 8. Johnson
- B. Performance: See the equipment schedules on the plans.
- C. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- D. Casing: 0.034-inch (0.85-mm) steel wall.
1. Casing Lining: Adhesive attached, 1-inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - a. Cover liner with nonporous foil.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections, size matching inlet size.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- E. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from 0 to 140 deg F (minus 18 to plus 60 deg C), shall be impervious to moisture and fungus, shall be suitable for 10-inch wg (2500-Pa) static pressure, and shall be factory tested for leaks.
- F. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 2. Damper Position: Normally open.

- G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

- H. Controls:

- 1. DDC controls to be provided and field mounted by others.

2.2 ACCESSORIES

- A. Provide a standard factory assembled hose kit piping package to consist of two 18" flexible hoses with EPDM inner lined hoses with stainless steel outer covering, strainer, pressure/temperature test port, automatic flow control device and two ball isolation valves. Control valves by others.

2.3 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Steel Cables: Galvanized steel complying with ASTM A 603.
- D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

2.4 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to ARI 880.
 - 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

- C. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance. Install units not more than 24" above ceilings unless noted specific heights are noted otherwise on the plans.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hangers: 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.

3.3 CONNECTIONS

- A. Install piping adjacent to air terminal unit to allow service and maintenance.
- B. Hot-Water Piping: In addition to requirements in other sections of the specifications connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- C. Connect ducts to air terminal units.
- D. Coordinate duct installations and specialty arrangements with Drawings.
- E. Make connections to fan powered air terminal units with flexible connectors.

3.4 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Air terminal unit will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.
 - 7. Assist the testing and balancing contractor as required.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

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SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Anemostat Products; a Mestek company.
 - 2. Carnes.
 - 3. Krueger
 - 4. METALAIRE, Inc.
 - 5. Nailor Industries Inc.
 - 6. Price Industries.
 - 7. Titus.
- B. See the equipment schedules on the plans for descriptions, accessories, performance, etc.

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 practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Roof hoods.

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1.5 COORDINATION

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

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.

- B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

2.2 FABRICATION, GENERAL

- A. Factory fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.

2.3 ROOF HOODS

- A. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 - 1. Acme Engineering & Mfg. Corporation.
 - 2. Aerovent.
 - 3. Carnes.
 - 4. Greenheck Fan Corporation.
 - 5. JencoFan.
 - 6. Loren Cook Company.
 - 7. PennBarry.
- B. Factory fabricated according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.
- C. Materials: Aluminum sheet, minimum 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood; suitably reinforced.
- D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.
- E. Bird Screening: Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire.

- F. Insect Screening: Aluminum, 18-by-16 (1.4-by-1.6-mm) mesh, 0.012-inch (0.30-mm) wire.
- G. Galvanized-Steel Sheet Finish:
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
 - 2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
- H. Capacities and Characteristics: As indicated on the equipment schedules on the plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- C. Secure gravity ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible.
- D. Install gravity ventilators with clearances for service and maintenance.
- E. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.
- F. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses.
- G. Label gravity ventilators.
- H. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- I. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

END OF SECTION 233723

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SECTION 235216 – FIRE-TUBE CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim, and accessories for heating hot water.

1.3 SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For boilers, boiler trim, and accessories.
 - 1. Include plans, elevations, sections, details, and attachments to other work.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Source quality-control test reports: Indicate and interpret test results for compliance with performance requirements before shipping.
- D. Field quality-control test reports: Indicate and interpret test results for compliance with performance requirements.
- E. Warranty: Standard warranty specified in this Section.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and sections, drawn to scale and coordinated with each other, using input from installers of the items involved.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For boilers to include in emergency, operation, and maintenance manuals.

1.6 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. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. AHRI Compliance: Boilers shall be AHRI listed and must meet the minimum efficiency specified under AHRI BTS-2000 as defined by Department of Energy in 10 CFR Part 431.
- E. ANSI Compliance: Boilers shall be compliant with ANSI Z21.13 test standards for US and Canada.
- F. CSA Compliant: Boilers shall be compliant with CSA certification.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

- A. Standard Warranty: Boilers shall include manufacturer's standard form in which 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:
 - a. Heat Exchanger, Pressure Vessel and Condensation Collection Basin shall carry a 10 year limited warranty against defects in materials or workmanship and failure due to thermal shock.
 - b. All other components shall carry a one year warranty from date of boiler start up.
 - 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the Lochinvar Crest Boiler as specified on Drawings or an equal product by one of the following:

1. Aerco
2. Fulton
3. Laars Heating Systems Company.
4. Lochinvar Corporation.
5. NTI
6. Raypak

2.2 CONSTRUCTION

- A. Description: Boiler shall be natural gas fired, fully condensing, and fire tube design. The boiler shall be factory-fabricated, factory-assembled, and factory-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.
- B. Heat Exchanger: The heater exchanger shall bear the ASME "H" stamp for 160 psi working pressure and shall be National Board listed. The heat exchanger shall be constructed of a fully welded 316L stainless steel and of fire tube design. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. Cast iron, aluminum, or condensing copper tube boilers will not be accepted.
- C. Efficiency: Boilers shall have an AHRI certified minimum thermal efficiency of 97 percent.
- D. Condensate Collection Basin: Fully welded 316L stainless steel and shall include a stainless steel combustion analyzer test port.
- E. Pressure Vessel: The pressure vessel shall be in accordance with ASME Section IV pressure vessel code. The pressure vessel shall be designed for a single-pass water flow to limit the water side pressure drop.
- F. Burner: Natural gas, forced draft single burner premix design. The burner shall be high temperature stainless steel with a woven Fecralloy outer covering to provide modulating firing rates. The burner shall be capable of the stated gas train turndown without loss of combustion efficiency.
- G. Blower: Boiler shall be equipped with a pulse width modulating blower system to precisely control the fuel/air mixture to provide modulating boiler firing rates for maximum efficiency. The burner firing sequence of operation shall include pre-purge, firing, modulation, and post-purge operation.
 1. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- H. Gas Train: The boiler shall be supplied with a negative pressure regulation gas train and shall be capable of 10:1 minimum turndown
- I. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
- J. Casing:

1. Jacket: Heavy gauge primed and painted steel jacket with snap-in closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Insulation: Minimum ½ inch thick, mineral fiber insulation surrounding the heat exchanger.
4. Combustion-Air Connections: Inlet and vent duct collars.

K. Characteristics and Capacities:

1. Heating Medium: Hot water.
2. Design Water Pressure Rating: 160 psi working pressure.
3. Safety Relief Valve Setting: 50 psig

2.3 TRIM

A. Safety Relief Valve:

1. Size and Capacity: 50 lb.
2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

B. Pressure Gage: Minimum 3-1/2 inch diameter. Gage shall have normal operating pressure about 50 percent of full range.

C. Drain Valves: Minimum NPS 3/4 or nozzle size with hose-end connection.

D. Condensate Neutralization Kit: Factory supplied condensate trap with condensate trip sensor, high capacity condensate receiver prefilled with appropriate medium.

2.4 CONTROLS

A. Boiler controls shall feature a standard, factory installed multi-color graphic LCD screen display with navigation dial and includes the following standard features:

1. Con-X-Us capable: Boiler shall have the ability to communicate remotely using the optional Con-X-Us software via a wireless or Ethernet connection.
2. Variable Speed Boiler Pump Control: Boiler may be programmed to send a 0-10V DC output signal to an ECM or VFD boiler pump to maintain a designed temperature rise across the heat exchanger. The boiler shall be able to operate in this mode with a minimum temperature rise of 20 degrees F and a maximum temperature rise of 60 degrees F.
3. Password Security: Boiler shall have a different password security code for the User and the Installer to access adjustable parameters.
4. Outdoor air reset: Boiler shall calculate the set point using a field installed, factory supplied outdoor sensor and an adjustable reset curve.
5. Pump exercise: Boiler shall energize any pump it controls for an adjustable time if the associated pump has been off for a time period of 24 hours.
6. Four pump control: Boiler shall have the ability to control the boiler pump, a system pump, a domestic hot water pump, and a domestic hot water recirculation pump.

7. Ramp delay: Boiler may be programmed to limit the firing rate based on six limits steps and six time intervals.
 8. Boost function: Boiler may be programmed to automatically increase the set point a fixed number of degrees (adjustable by installer) if the setpoint has been continuously active for a set period of time (time adjustable by installer). This process will continue until the space heating demand ends.
 9. PC port connection: Boiler shall have a PC port allowing the connection of PC boiler software.
 10. Time clock: Boiler shall have an internal time clock with the ability to time and date stamp lock-out codes and maintain records of runtime.
 11. Maintenance reminder: Boiler shall have the ability to display a yellow colored, customizable maintenance notification screen. All notifications are adjustable by the installer based upon months of installation, hours of operation, and number of boiler cycles.
 12. English Error codes: Boiler shall have a user interface that displays a red error screen with fault codes that are displayed in English and include a date and time stamp for ease of servicing.
 13. Anti-cycling control: Boiler shall have the ability to set a time delay after a heating demand is satisfied allowing the boiler to block a new call for heat. The boiler will display an anti-cycling blocking on the screen until the time has elapsed or the water temperature drops below the anti-cycling differential parameter. The anti-cycling control parameter is adjustable by the installer.
 14. Space Heating Night setback: Boiler may be programmed to reduce the space heating temperature set point during a certain time of the day.
 15. Freeze protection: Boiler shall turn on the boiler and system pumps when the boiler water temperature falls below 45 degrees. When the boiler water temperature falls below 37 degrees the boiler will automatically turn on. Boiler and pumps will turn off when the boiler water temperature rises above 43 degrees.
 16. Isolation valve control: Boiler shall have the ability to control a 2-way motorized control valve. Boiler shall also be able to force a fixed number of valves to always be energized regardless of the number of boilers that are firing.
 17. BMS integration with 0-10V DC input: The Control shall allow an option to Enable and control set point temperature or control firing rate by sending the boiler a 0-10V input signal.
 18. Data logging: Boiler shall have non-volatile data logging memory including last 10 lockouts, space heat run hours, domestic hot water run hours and ignition attempts. All data should be visible on the boiler screen.
- B. The boiler shall have a built in Cascade controller to sequence and rotate lead boiler to ensure equal runtime while maintaining modulation of up to 8 boilers of different btu inputs without utilization of an external controller. The factory installed, internal cascade controller shall include:
1. Lead lag: The Control module shall allow only one boiler to fire at the beginning of a call for heat. Once the lead boiler is in full fire and the control calculates that additional heat is required it will call on an additional boiler as needed.
 2. Efficiency optimization: The Control module shall allow multiple boilers to simultaneously fire at minimum firing rate in lieu of Lead/Lag.
 3. Rotation of lead boiler: The Control module shall change the lead boiler every hour for the first 24 hours after initializing the Cascade. Following that, the leader will be changed once every 24 hours.

- C. Boiler operating controls shall include the following devices and features:
 - 1. Set-Point Adjust: Set points shall be fully adjustable by the installer.
 - 2. Sequence of Operation: Factory installed controller to modulate burner firing rate to maintain system water temperature in response to call for heat.
- D. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation and include:
 - 1. High Temperature Limit: Automatic and manual reset stops burner if operating conditions rise above maximum boiler design temperature. Limit switch to be manually reset on the control interface.
 - 2. Low-Water Cutoff Switch: Electronic probe shall prevent burner operation on low water. Cutoff switch shall be manually reset on the control interface.
 - 3. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
 - 4. High and Low Gas Pressure Switches: Pressure switches shall prevent burner operation on low or high gas pressure. Pressure switches to be manually reset on the control interface.
 - 5. Blocked Drain Switch: Blocked drain switch shall prevent burner operation when tripped. Switch to be manually reset on the control interface.
 - 6. Low air pressure switch: Pressure switches shall prevent burner operation on low air pressure. Switch to be manually reset on the control interface.
 - 7. Optional Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for any lockout conditions.
- E. Building Automation System Interface:
 - 1. Boiler shall have the ability to receive a 0-10V system from a building management system and control by the following:
 - a. 0-10V DC input to control Modulation or Setpoint
 - b. 0-10V DC input from Variable speed Boiler pump
 - c. 0-10V DC output signal to a Variable speed system pump
 - d. 0-10V DC input Enable/Disable signal
 - 2. Factory installed Modbus gateway interface to enable building automation system to monitor, control, and display boiler status and alarms.

2.5 ELECTRICAL POWER

- A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.
- B. Single-Point Field Power Connection: Factory-installed and factory-wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
- C. Electrical Characteristics:

1. See Drawings
2. Voltage
 - a. 120V / 1PH
3. Frequency: 60 Hz

2.6 VENTING

- A. Exhaust flue must be Category IV approved PVC, CPVC, PP or stainless steel sealed vent material from one of the approved manufacturers listed in the Installation and Operation manual. Boilers exhaust vent length must be able to extend to 100 equivalent feet.
- B. Intake piping must be of approved material as listed in the Installation and Operations manual. Boilers intake pipe length must be able to extend to 100 equivalent feet.
- C. Boiler venting and intake piping configuration shall be installed per one of the approved venting methods shown in the Installation and Operation manual.
- D. Boilers using common venting must only include like models and the optional common vent damper. Contact the factory for common vent sizing.
- E. Boiler shall come standard with a flue sensor to monitor and display flue gas temperature on factory provided LCD display.
- F. Refer to manufacturer's Installation and Operations manual for detailed venting instructions and approved manufacturers.

2.7 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 ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, 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 boiler performance, maintenance, and operations.
 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in of 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. Install equipment on 4" concrete housekeeping pad.
- B. Install gas-fired boilers according to NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Install boilers level on concrete bases. Concrete base is specified in Section 230500 "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
- B. When installing piping adjacent to boiler, allow space for service and maintenance of condensing boilers. Arrange piping for easy removal of condensing boilers.
- C. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.
- D. Install condensate piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.
- 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 tapings 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.
 - 2. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, and Stacks."
- I. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

- J. Connect wiring according to Section 260519 "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. Tests and Inspections:
 - 1. Perform installation and startup checks according to manufacturer's written instructions. Complete startup form included with Boiler and return to Manufacturer as described in the 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.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- D. Performance Tests:
 - 1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
 - 2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
 - 3. Perform field performance tests to determine capacity and efficiency of boilers.
 - 4. Repeat tests until results comply with requirements indicated.
 - 5. Provide analysis equipment required to determine performance.
 - 6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
 - 7. Notify Architect in advance of test dates.
 - 8. Perform a combustion analysis after installation and adjust gas valve per the Installation and Operations manual and note in startup report.
 - 9. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

- A. Engage a factory representative or a factory-authorized service representative for boiler startup and to train Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 235216

SECTION 235523.16 - HIGH-INTENSITY, GAS-FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. High-intensity, infrared, gas-fired, radiant heaters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 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.

1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.
 - a. Heater Components: Three years.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. UL listed and labeled, with UL label clearly visible on units.
- 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 HIGH-INTENSITY, INFRARED, GAS-FIRED, RADIANT HEATERS

- A. General:
 1. Factory assembled, single-piece infrared radiant heating unit for overhead mounted space or area heating application. Supplied with the heater will be all necessary factory installed wiring, piping, and controls required prior to field installation and start-up.
- B. Primary Emitting Surface:
 1. General:
 - a. The primary radiant surface will be comprised of a panel of porous ceramic burner tiles with indentation surface technology creating 372 indentations in each tile radiating surface and increasing the emitting surface area by 50%.
 - b. Ceramic tiles will have a homologous grid of approximately 3400 needled perforations that differ not more than +/- 0.001 inch (0.03 mm) in diameter to create a homogeneous radiant surface.
 - c. Ceramic tiles will have machined perimeter edges so that the burner panel assembly requires no gasket material between contiguous tiles.
 - d. The perimeter of the ceramic tile burner panel will be seated to the heater body utilizing stainless steel gasket material.
 - e. The ceramic tile burner will attain an operating surface temperature of 1740°F (950°C). The ceramic tiles will be able to withstand temperatures of 2012°F (1100°C).
 - f. The ceramic tiles will have an inner porosity of 44% or more to ensure sufficient thermal insulation between radiant burner surface and mixing chamber
 - g. A chrome-nickel stainless steel refractory expanded mesh will be located in close proximity facing the radiating surface of the emitter tile panel to exploit combustion heat and maximize radiant performance. The refractory mesh will be formed with undulated profile to maintain shape and proximity to the burner face.
- C. Secondary Emitting Surface

1. General:

- a. A secondary radiant surface will be created by a reflector housing, closed in two dimensions to be in contact with the continuous stream of flue gases
- b. Heater body and reflectors will be designed and assembled to a continuous one piece unit without gaps between heater body and reflectors.
- c. Exhaust gases will heat the interior reflector surfaces to a temperature of 930°F (500°C) so as to emit low intensity infrared radiant heat (dark radiator)
- d. Heater reflectors will be constructed of high grade steel clad with cold-bonded polished aluminum layer to reach reflectance of at least 90% and ensure durable corrosion protection
- e. Heater body and reflectors will be fully insulated with ceramic fiber insulation on the exterior surface. The heater with insulation will be covered completely within an aluminized steel housing.

D. Heater Body:

1. General:

- a. Heater body and reflectors will be constructed of high grade steel clad with highly corrosion resistant cold-bonded aluminum.
- b. Heater body and reflectors will be assembled using press fit and crimp joint construction to provide flexibility during expansion and contraction that result from operation.
- c. The heater body and reflectors will be fully insulated with ceramic fiber on the exterior surface: 1 inch (25 mm) each end; 0.5 inch (13 mm) all other surfaces. The insulation will be protected with an aluminized steel cover.
- d. The ceramic insulation material will be a high temperature aluminum and silicate fiber with classification temperature: 2300°F (1260°C); and thermal conductivity: 0.023 Btu/ft-h-°F(0.04 W/mK).

E. Mixing Chamber as Additional Heat Exchanger:

1. General:

- a. Mixing Chamber will be constructed and located to be an additional exchanger of heat from flue gases to gas/air fuel mixture and will ensure a homogeneous mixture of fuel gas and air.
- b. A gas/air fuel mixing chamber will be formed by the assembly of reflectors and body.
- c. The gas/air fuel is introduced to the mixing chamber through a single venturi located at the end of the chamber.
- d. The gas/air fuel mixing chamber will ensure that the heat loss of combustion is reduced by heat exchange to preheat the gas/air mixture up to 480°F (250°C) and pressurize the gas/air mixture for consistent and balanced supply to the ceramic tile burner panel. Angle mounted heater will have the mixing chamber located in the upper position to realize the additional heat exchange.

F. Controls and Safeties:

1. General:
 - a. Each individual ceramic tile burner panel will have solid state direct spark ignition and flame sensor control that is dedicated to secure the operation of that burner panel
 - b. Heater gas and ignition controls will be readily accessible for servicing.
2. Ignition and Flame Control:
 - a. Heater will be complete with a low voltage (25Vac), solid state direct spark ignition and ionization flame sensing control module. Electrical Rating: 25Vac, 60Hz with current rating of 0.2A at 25Vac
 - b. Heater will be complete with an igniter/sensor with separate electrodes for spark ignition and flame sensing.
 - c. The ionization module will sense the presence of main burner flame and discontinue spark ignition. If the burner fails to ignite within the trial-for-ignition period, the flame control will go into safety lockout. Reset of the control is manually done from the thermostat.
 - d. The ionization module will check for a false flame condition (short to ground) and lock out if a false flame condition is present.
 - e. The ignition module will have a 21 second trial-for-ignition period
 - f. The ignition module will open the main gas valve and generate 30,000 volts at the spark igniter for direct ignition of the burner.
 - g. On a loss of burner flame the timed trial-for-ignition is repeated. Safety lockout occurs if flame is not reestablished within the trial-for-ignition period. Reset of the control is manually done from the thermostat.
 - h. To complete the direct spark ignition system the system will incorporate a gas control, 25Vac transformer, and:
 - 1) For space heating application an Infrared Setback Thermostat as supplied by the manufacturer of the heater
3. Gas Control:
 - a. Heater will be complete with a direct ignition gas control with a manual valve, two automatic operators, and a pressure regulator Electrical Rating: 24Vac, 60Hz; draw 0.5A with both operators energized
 - b. The gas control will have an inlet pressure tap and an outlet pressure tap to facilitate measurement of gas supply and manifold pressures during servicing.
 - c. Heater will be complete with a ½" pipe nipple and ½" union with ½" female NPT for connection to the gas supply.
4. Heater Zone Temperature Control:
 - a. Field supplied control by others, to integrate into the building management system.

G. Capacities and Characteristics: As shown on the schedules on the plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54.
- B. Suspended Units: Mount to substrate using rigid mounting kits or brackets, supplied by manufacturer or manufactured.
 - 1. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. Maintain manufacturers' recommended clearances for combustibles.
- D. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping." Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
 - 1. Gas Connections: Connect gas piping to radiant heaters according to NFPA 54.
- E. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.
- F. Electrical Connections: Comply with applicable requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 1. Install electrical devices furnished with heaters but not specified to be factory mounted.
- G. Adjust initial-temperature set points.
- H. Adjust burner and other unit components for optimum heating performance and efficiency.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Verify bearing lubrication.
 - 3. Verify proper motor rotation.
 - 4. 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.
- B. and inspections.

- C. Prepare test and inspection reports.

END OF SECTION 235523.16

SECTION 235533.16 - GAS-FIRED UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes gas-fired unit heaters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of gas-fired unit heater.
 - 1. Include rated capacities, operating characteristics, and accessories.
- B. Shop Drawings: For gas-fired unit heaters. Include plans, elevations, sections, and attachment details.
 - 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members to which equipment will be attached.
 - 2. Items penetrating roof and the following:
 - a. Vent and gas piping rough-ins and connections.
- B. Field quality-control reports.
- C. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace heat exchanger of gas-fired unit heater that fails in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Capacities and Characteristics: As indicated in the schedules on the plans.

2.2 MANUFACTURED UNITS

- A. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
- B. Gas Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- C. Type of Venting: Indoor, separated combustion, power vented.
- D. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
 - 1. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
 - 2. Discharge Louvers: Independently adjustable blades.
- E. Options & Accessories:
 - 1. Four-point suspension kit.
 - 2. Vent terminal/combustion air kit (see plan for vertical or horizontal).
 - 3. Controls: By others for integration into the BAS.
- F. Heat Exchanger: Aluminized steel.
- G. Burner Material: Aluminized steel with stainless-steel inserts.
- H. Propeller Unit Fan:

1. Propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
 2. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
- I. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
1. Gas Control Valve: Two stage.
 2. Ignition: Electronically controlled electric spark with flame sensor.
 3. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
 4. Vent Flow Verification: Differential pressure switch to verify open vent.
 5. Control transformer.
 6. High Limit: Thermal switch or fuse to stop burner.
- J. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install and connect gas-fired unit heaters and associated gas and vent features and systems according to NFPA 54, applicable local codes and regulations, and manufacturer's written instructions.

3.2 EQUIPMENT MOUNTING

- A. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
- B. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.

3.3 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 gas-fired unit heater, allow space for service and maintenance.
- C. Gas Piping: Comply with Section 231123 "Facility Natural-Gas Piping Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Verify bearing lubrication.
 - 3. Verify proper motor rotation.
 - 4. 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.
- B. Gas-fired unit heater will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain gas-fired unit heaters.

END OF SECTION 235533.16

SECTION 237223 - AIR TO AIR ENERGY RECOVERY VENTILATOR

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. Heat wheels in packaged, outdoor, total energy-recovery units.

1.3 SYSTEM DESCRIPTION

- A. The fresh air ventilation system shall consist of an energy recovery ventilator, incorporating a high-efficiency paper, cross-flow heat exchanger core in order to provide both sensible and latent heat recovery.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For packaged, outdoor, heat-wheel, energy-recovery units.
 - 1. Include plans, elevations, sections, details, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, lifting requirements, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, roof plans, elevations, and other details, drawn to scale and coordinated with each other, using input from installers of items involved.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 COORDINATION

- A. Coordinate sizes and locations of building openings and duct connections with actual equipment provided.

1.8 QUALITY ASSURANCE

- A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.
- B. All wiring shall be in accordance with the National Electric Code (NEC).
- C. The system shall be certified in accordance with Air Conditioning, Heating, and Refrigeration Institute's (AHRI) Standard 1060 and bear the AHRI Certified label.
- D. The heat exchanger core shall be tested in accordance with Underwriters Laboratories (UL) 723 and shall have a flame spread rating of not more than 25, and a smoke developed rating of not more than 50.
- E. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, outdoor, heat-wheel, energy-recovery units that fail in materials or workmanship within specified warranty period. This warranty applies to compressor and all parts and is limited in duration to ten (10) years starting from the "installation date" which is defined below:
 - 1. The installation date is the date that the unit undergoes factory start up, but no later than 18 months after the manufacture date noted on the unit's rating plate.

PART 2 - PRODUCTS

2.1 ENERGY RECOVER VENTILATOR

- A. Unit Cabinet:
 - 1. The cabinet shall be constructed of galvanized steel plate.
 - 2. The unit shall be internally insulated with a self-extinguishing urethane foam.
- B. Fans:
 - 1. The fans shall be direct-drive, forward-curved centrifugal type with statically and dynamically balanced impellers with extra-high, high, and low fan speeds.
 - 2. The fan motor(s) shall operate on 208-230 volts, 1 phase, 60 hertz.

3. The air flow rate shall be available in extra-high, high, and low settings.
4. The fan motor shall be thermally protected.

C. Filter:

1. The supply and exhaust air streams shall be filtered prior to entering the heat exchanger core by means of a multidirectional fibrous fleece filter.

D. Heat Exchanger:

1. The heat exchanger element shall consist of a specially processed, nonflammable, HEP (high efficiency paper) heat exchanger designed to allow the exchange of both sensible and latent energy between the supply and exhaust airstreams. The core material shall be tested as specified in UL 723 and have a flame spread rating of not more than 25, and a smoke developed rating of not more than 50.

E. Electrical:

1. A separate power supply will be required of 208-230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

F. Control:

1. The unit shall be compatible with Daikin D-III net via the F1/F2 terminal.
2. The unit shall be capable of the following methods of control:
 - a. Independent control – The unit shall be operable directly by a local remote controller.
 - b. Interlocked control – The unit shall be operable in conjunction with a VRV or Sky Air system by a local remote controller.
 - c. Centralized control – The unit shall be operable by a centralized control without the need for a local remote controller to be connected.
3. The unit shall be capable of the following modes of operation:
 - a. Energy recovery
 - b. Bypass ventilation – The unit shall be capable of bypass ventilation which diverts air flow around the heat exchanger core. No energy recovery is performed.
 - c. Auto Mode – The unit shall be capable of automatically determining the need for performing energy recovery or bypassing the heat exchanger core based on the current fan coil operation mode and the current indoor and outdoor temperatures.
 - d. Fresh-up Mode (supply) – The unit shall be capable of entering Fresh-up Supply operation in which the incoming supply air ratio is greater than the exhaust air ratio.
 - e. Fresh-up Mode (exhaust) – The unit shall be capable of entering Fresh-up Exhaust operation which in the incoming supply air ratio is less than the exhaust air ratio.
 - f. Night Time Free Cooling – The unit shall be capable of Night Time Free Cooling in which the unit will automatically energize to lower the space temperature based

on the current outdoor temperature, the current indoor temperature, current set point, and the operating state of the indoor fan coils.

G. Installation

1. The unit shall be capable of inverted installation if required by ductwork and access clearance requirements.

H. Operating Range

1. The equipment operating range shall be 5°F DB ~ 122°F DB* and 80%RH or less.

I. Capacities, Characteristics and Accessories

1. As shown on the equipment schedules on the plans.

PART 3 - EXECUTION

3.1 INSTALLATION OF AIR TO AIR ENERGY RECOVERY VENTILATORS

- A. Examine casing insulation materials and filter media before packaged, outdoor, energy-recovery unit installation. Replace insulation materials and filter media that are wet, moisture damaged, or mold contaminated.
- B. Install energy recovery ventilator per manufacturer's instructions with recommended service clearances and access.
- C. Equipment Mounting:
 1. Install deck-mounted energy-recovery units on spring vibration isolation curb or platform.
 2. Install suspended units suspended and braced from outdoor structural-steel support frame, using threaded steel rods and spring hangers.
- D. Install units with clearances for service and maintenance.
- E. Do not operate equipment fans until temporary or permanent filters are in place. Replace temporary filters used during construction and testing with new, clean filters prior to final inspection.

3.2 DUCTWORK CONNECTIONS

- A. Comply with requirements for ductwork in accordance with Section 233113 "Metal Ducts."
- B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to unit, allow service and maintenance.
- C. Connect piping to units mounted on vibration isolators with flexible connectors.
- D. Condensate Drain Piping: See Section 232113 "Hydronic Piping" for pipe type. Install condensate drain piping from drain pans to nearest floor drain, same size as condensate drain connection.
 - 1. Construct deep trap at connection to drain pan, and install cleanouts at changes in direction.

3.4 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections with assistance of factory-authorized service representative.
- C. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 237223

SECTION 238127 – DUCTLESS MINI-SPLIT-SYSTEM AIR-CONDITIONERS

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 ductless mini-split-system air-conditioning and heat-pump units consisting of separate indoor evaporator-fan units and outdoor compressor-condenser components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.4 INFORMATIONAL SUBMITTALS

- A. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Startup service reports.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."

- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: Five year(s) from date of Substantial Completion.
 2. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the basis of design products shown on the plans or an equal product by one of the following:
 1. Carrier
 2. Daikin
 3. Johnson Controls
 4. Lennox
 5. LG
 6. Mitsubishi Electric & Electronics USA, Inc.
 7. Samsung
 8. SANYO North America Corporation.
 9. Trane

2.2 INDOOR UNITS

- A. All Indoor units shall be complete with factory mounted controls, fans, coils, electronic expansion valves (EEVs), condensate drain pans, condensate drain lift pumps, filters, refrigerant pipe temperature sensors and wiring terminal blocks. The units shall have multiple-speed constant-flow fan assemblies with direct drive digitally commutated motors.
- B. All indoor unit coils shall pressure tested with dry nitrogen to a minimum of 500 psi in the field, coils and indoor units containing coils not rated for 500 psi or more shall not be permitted.

C. Wall-Mounted Indoor Unit

1. General: The unit shall be wall-mounted indoor unit section with a slim silhouette. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function.
2. Unit Cabinet:
 - a. The casing shall have a white finish.
 - b. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and four (4) directions for draining shall be standard.
 - c. There shall be a separate plate which secures the unit firmly to the wall.
3. Fan:
 - a. The indoor fan shall be an assembly with Cross-flow fan direct driven by a single motor.
 - b. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
 - c. The indoor fan shall consist of various speeds.
4. Filter:
 - a. Return air shall be filtered by means of an easily removable, washable filter.
5. Coil:
 - a. The indoor coil shall be of nonferrous construction with Slit fins on copper tubing.
 - b. The tubing shall have inner grooves for high efficiency heat exchange.
 - c. All tube joints shall be brazed with phos-copper or silver alloy.
 - d. The coils shall be pressure tested at the factory.
 - e. A condensate pan and drain shall be provided under the coil.
 - f. The fins of coil are coated hydrophilic paints.

2.3 OUTDOOR UNITS (5 TONS (18 kW) OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Inverter driven scroll hermetic.
 - b. Refrigerant Charge: R-410A.
 - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.

3. Heat-Pump Components (where indicated): Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 0 deg F.

2.4 ACCESSORIES

- A. Thermostat: Manufacturer's standard wired 7 day programmable controller. No wireless controllers will be accepted.
- B. Automatic-reset timer to prevent rapid cycling of compressor.
- C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- D. Condensate pump and automatic switch to shut down unit on pump failure.
- E. Drain Hose: For condensate.

2.5 CAPACITIES AND CHARACTERISTICS

- A. As indicated on the equipment schedules on the plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install units level and plumb.
- C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- D. Equipment Mounting:
 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in other sections of the specifications
 2. Install roof-mounted, compressor-condenser components on equipment housekeeping platforms as detailed on the plans.
- E. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

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SECTION 238128 - VARIABLE REFRIGERANT AIR CONDITIONERS

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. VR Outdoor Units.
 - 2. Outdoor Heat Recovery Unit Rack Systems.
 - 3. Branch Selector Boxes.
 - 4. VR Indoor Fan Coil Units.
 - 5. VR System Controls.

1.3 SYSTEM DESCRIPTION

- A. The variable capacity, heat recovery air conditioning system shall be as specified. The system shall consist of multiple evaporators, branch selector boxes, piping joints and headers, a multi-pipe refrigeration distribution system using PID control, and VR outdoor units. The outdoor units are a direct expansion (DX), air-cooled heat recovery, multi-zone air-conditioning system with variable speed driven compressors using R-410A refrigerant. The outdoor unit may connect an indoor evaporator capacity up to 130% of the outdoor condensing unit capacity. All zones are each capable of operating separately in either heating or cooling mode with individual temperature control.
- B. The outdoor unit shall be interconnected to indoor unit models and shall range in capacity from 7,500 Btu/h to 96,000 Btu/h in accordance with each available indoor units.
- C. Operation of the system shall permit either individual cooling or heating of each fan coil simultaneously or all of the fan coil units associated with one branch cool/heat selector box. Each fan coil or group of fan coils shall be able to provide set temperature independently via a local controller.
- D. Branch selector boxes shall be located as shown on the drawing. The branch selector box shall consist of control valves, refrigerant control piping and electronics to facilitate communications between the box and main processor and between the box and indoor units. The branch selector box shall control the operational mode of the subordinate indoor units.
- E. A full charge of R-410A for the condensing unit only shall be provided in the condensing unit.

1.4 VR REQUIRED FEATURES

- A. Voltage Platform: Heat pump and heat recovery condensing units shall be available with a 208-230V/3/60 power supply.
- B. Advanced Zoning: A single system shall provide for up to 64 zones.
- C. Autocharging: Each system shall have a refrigerant auto-charging function.
- D. Charge Checking: Each system shall have a refrigerant charge checking function.
- E. Defrost Heating: Each system shall maintain continuous heating during defrost operation.
- F. Oil Return Heating: Each system shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.
- G. Low Ambient Cooling: Each system shall be capable of low ambient cooling operation to 5°F DB. Unit shall continue to heat without shutting down all the way down to -40°F DB.
- H. Independent Control: Each indoor unit shall use a dedicated electronic expansion valve for independent control.
- I. VFD Inverter Control: Each condensing unit shall use a high efficiency, variable speed “inverter” compressor coupled with inverter fan motors for superior part load performance.
- J. Compressor capacity shall be modulated automatically to maintain constant suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads.
- K. Indoor units shall use PID to control superheat to deliver a comfortable room temperature condition and optimize efficiency.
- L. Configurator Software: Each system shall be available with configurator software package to allow for remote configuration of operational settings and also for assessment of operational data and error codes. If this software is not provided by an alternate manufacturer, for each individual outdoor unit the contractor shall do the settings manually and keep detailed records for future maintenance purposes.
- M. Flexible Design:
 - 1. Systems shall be capable of up to 540ft (640ft equivalent) of linear piping between the condensing unit and furthest located fan coil unit.
 - 2. Systems shall be capable of up to 3,280ft total “one-way” piping in the piping network.
 - 3. Systems shall have a vertical (height) separation of up to 295ft between the condensing unit and the fan coil units.
 - 4. Systems shall be capable of 295ft from the first branch point.
 - 5. The outdoor unit shall connect an indoor evaporator capacity up to 130% of the outdoor condensing unit capacity.
 - 6. Systems shall be capable of 98ft between fan coil units.

- 7. Condensing units shall be supported with a fan/fan motor ESP up to 0.32" WG as standard to allow connection of discharge ductwork and to prevent discharge air short circuiting.
- N. Simple Wiring: Systems shall use follow the manufacturer's standard.
- O. Advanced Diagnostics: Systems shall include a self diagnostic, auto-check function to detect a malfunction and display the type and location.
- P. Advanced Controls: Each system shall have at least one remote controller capable of controlling up to 16 fan coil units.
- Q. Each system shall be capable of integrating with open protocol BACnet to tie into the campus wide Alerton Building Automation System.
- R. Low Sound Levels: Each system shall use indoor and outdoor units with quiet operation as low as 27 dB(A).

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: The system must be installed by a manufacturer trained contractor/dealer. The bidders shall be required to submit training certification proof with bid documents. The installing contractor must also be able to document successful installation of variable refrigerant volume/ variable refrigerant flow systems of the manufacturer and models included in the bid, covering a conditioned floor area of at least 100,000 square feet in at least three separate locations combined. These systems must have been installed with his manpower and under his direct supervision and have been in operation for a minimum of 12 months at the time of this bid date. The contractor must furnish contact information for individuals employed at these locations and with knowledge of the systems at these locations that can verify the successful installation, startup and follow up support of the contractor with these installed systems. Verification of this information and references from these individuals is to be performed by the Construction Manager for a bid to be accepted. The Construction Manager is responsible to confirm that the VRV contractors and equipment manufacturers are qualified based on these requirements prior to acceptance of a bid.
- B. The mechanical contractor's installation price shall be based on the system's installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.
- C. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.
- D. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
- E. All units must meet or exceed the 2012 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be tested and published in the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230 Certified Product Directory and ISO Standard 13256-1.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Unit shall be stored and handled according to the manufacturer's recommendation.

1.7 ACTION SUBMITTALS

- A. Manufacturer's certification of the contractor for installation and service of the equipment to be provided.
- B. Contractor's references of installation of VR systems covering at least 100,000 square feet.
- C. Contractor's references employed at locations where contractor has installed VR systems.
- D. Product Data: For each type of product indicated.
- E. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- F. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.8 INFORMATIONAL SUBMITTALS

- A. Warranty: Sample of special warranty.
- B. Startup service reports.

1.9 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Startup refrigerant test results (see 3.03, C, 5)
- C. System commissioning report by a factory authorized representative.

1.10 WARRANTY

- A. The units shall be covered by the manufacturer's limited warranty for a period of one (1) year from date of Substantial Completion.
- B. 10 Year Parts and Compressor Warranty: The units shall have a manufacturer's all-parts warranty for a period of ten (10) years from date of factory certified start-up. The compressors shall also have a manufacturer's warranty of ten (10) years from date of factory certified start up.
- C. Warranty shall include a 1-year labor warranty to repair or replace equipment or materials that fail during the first year of operation following substantial completion.

- D. Factory Check-Test, Start-Up & Warranty Registration: All systems shall be started up and commissioned by a factory service technician, not by the installing mechanical contractor. Before start-up, the factory technician shall inspect the system and point out any visible installation oversights the mechanical contractor or other trades made that violate manufacturer's installation requirements. Factory start-up technicians shall be commercially licensed refrigeration technicians with EPA Section 608 Universal Certification. Technicians must have record of ten (10) satisfactory start-ups on large VR projects (minimum 100 tons) on proposed manufacturer's VR system. Technicians to have a minimum five (5) years' experience in HVAC service, and must hold current certifications for the system manufacturer for commissioning, service, troubleshooting, and controls. The factory service technician shall complete all warranty registration paperwork and submit a copy to the owner for their records.

1.11 INSTALLATION REQUIREMENTS

- A. The system must be installed by manufacturer factory trained contractor. The bidders shall be required to submit training certification proof with bid documents. The mechanical contractor's installation price shall be based on systems installation requirements. The mechanical contractor bids with complete knowledge of the HVAC system requirements.
- B. The mechanical contractor shall maintain training certification certificates of all employees working on the project side related to the VR systems. These certificates will be kept in the construction trailer of the Construction Manager. The Construction Manager may review certified payroll documentation to verify that all the VR installers have a certificate on file.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide the basis of design products shown on the plans by:
1. Daikin Applied.
- B. Bidder may propose a voluntary deduct alternate to the basis-of-design system by Daikin and bid an equal product by one of the following:
1. Lennox
 2. LG Electronics.
 3. Mitsubishi.
- C. System designs for variable refrigerant systems can vary widely depending on the manufacturer. The information included on the construction documents is for the basis of design equipment only. Requirements for equipment from manufacturers other than the basis of design will vary. Equipment manufacturers other than the identified basis of design are permitted; however, the Contractor shall be responsible for ALL design and additional costs associated with installation of equipment from an alternate manufacturer in lieu of the basis of design.

- D. All components and/or materials shown on the plans may not be required by all equipment brands, e.g. condensate drains from Branch Controllers/Selectors. Components or materials shown on the plans for the basis of design equipment but not required by another proposed brand for a complete and functional system are not required to be included in the bid.

2.2 OUTDOOR UNIT

- A. General: The outdoor unit is designed specifically for use with VR components.

1. The outdoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports and refrigerant regulator.
2. High/low pressure gas line, liquid and suction lines must be individually insulated between the outdoor and indoor units.
3. The outdoor unit can be wired and piped with outdoor unit access from the left, right, rear or bottom.
4. The connection ratio of indoor units to outdoor unit shall be permitted up to 130%.
5. Each outdoor system shall be able to support the connection of up to 64 indoor units dependent on the model of the outdoor unit.
6. The sound pressure level standard shall be that value as listed in the Daikin engineering manual for the specified models at 3 feet from the front of the unit. The outdoor unit shall be capable of operating automatically at further reduced noise during night time.
7. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.
8. The unit shall incorporate an auto-charging feature and a refrigerant charge check function.
9. The outdoor unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
10. The following safety devices shall be included on the condensing unit; high pressure switch, control circuit fuses, crankcase heaters, fusible plug, high pressure switch, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
11. To ensure the liquid refrigerant does not flash when supplying to the various fan coil units, the circuit shall be provided with a sub-cooling feature.
12. Oil recovery cycle shall be automatic occurring when oil level indicator is activated.
13. The outdoor unit shall be capable of heating operation at -40 deg F dry bulb ambient temperature without additional low ambient controls.
14. The system shall continue to provide heat to the indoor units in heating operation while in the defrost mode.

- B. Unit Cabinet:

1. The outdoor unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.

- C. Fan:

1. The condensing unit shall consist of two or more propeller type, direct-drive fan motors that have multiple speed operation via a DC (digitally commutating) inverter.
2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG.
3. The fan shall be a vertical discharge configuration.
4. Nominal sound pressure levels shall range from 61 dB(A) on size 96 units to 70 dB(A) on size 456 units.
5. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
6. The fan motor shall be provided with a fan guard to prevent contact with moving parts.

D. Condenser Coil:

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The heat exchanger on the condensing units shall be manufactured from seamless copper tube with internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins are to be covered with an anti-corrosion coating as standard with a salt spray test rating of 1000hr (ASTM B117 and Blister Rating:10), Acetic acid salt spray test: 500hr (ASTM G85 and Blister Rating:10).
5. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.
6. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for bottom plate heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.

E. Compressor:

1. Inverter scroll compressors shall be variable speed controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency or STD ON/OFF) shall be controlled to eliminate deviation from target value.
2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G-type" with a maximum speed of 7,980 rpm.
3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
4. The capacity control range shall be as low as 6% to 100%.
5. Each non-inverter compressor shall also be of the hermetically sealed scroll type.
6. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.

7. Oil separators shall be standard with the equipment together with an intelligent oil management system.
8. The compressor shall be spring mounted to avoid the transmission of vibration.
9. The compressor shall have a dome temperature sensor to shut down compressor at extreme temperatures and extend compressor life.
10. In the event of compressor failure, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.
11. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours.

F. Electrical:

1. The power supply to the outdoor unit shall be 208-230 or 460 volts, 3 phase, 60 hertz +/- 10% as scheduled.
2. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded, stranded 2 conductor cable.
3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.
4. The control wiring lengths shall be as shown below.

	Outdoor to Indoor Unit	Outdoor to Central Controller	Indoor Unit to Remote Control
Control Wiring Length	6,665 ft	3,330 ft	1,665 ft
Wire Type	Manufacturer's Standard Recommendation		

G. Operating Range

1. The operating range in cooling will be 23 deg F DB ~ 110 deg F DB.
2. The operating range in heating will be -40 deg F DB – 77 deg F DB / -40 deg F WB – 60 deg F WB. Simultaneous cooling/heating operating range will be 22 deg F WB ~ 60 deg F WB.

2.3 BRANCH SELECTOR BOX FOR HEAT RECOVERY SYSTEM

A. General: The branch selector boxes are designed specifically for use with VR heat recovery system components.

1. These selector boxes shall be factory assembled, wired, and piped.
2. The branch controllers must be run tested at the factory.
3. These selector boxes must be mounted indoors.

4. When simultaneously heating and cooling, the units in heating mode shall energize their subcooling valve.

B. Unit Cabinet:

1. The units shall have a galvanized steel plate casing.
2. Each cabinet shall house valves for refrigerant control per branch.
3. The cabinet shall contain one subcooling heat exchanger per branch.
4. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

C. Refrigerant Valves:

1. The unit shall be furnished with valves per branch to control the direction of refrigerant flow.
2. In multi-port units, each port shall have its own electronic expansion valves.
3. Multiple indoor units may be connected to a branch selector box with the use of a joint provided they are within the capacity range of the branch selector.

D. Condensate Removal:

1. The unit shall not require provisions for condensate removal. A safety device or secondary drain pan shall be installed by the mechanical contractor to comply with the applicable mechanical code, if an alternate manufacturer is selected.

E. Electrical:

1. The unit electrical power shall be 208/230 volts, 1 phase, 60 hertz.
2. The unit shall be capable of operation within the limits of 187 volts to 255 volts.
3. The minimum circuit amps (MCA) shall be 0.1 and the maximum overcurrent protection amps (MOP) shall be 15.
4. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded 2 conductor cable.

2.4 VR INDOOR FAN COIL UNITS

A. 4 Way Ceiling Cassette Unit (3'x3'):

1. General: The indoor unit model shall be a ceiling cassette fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with an air panel grill. It shall be available from 7,500 Btu/h to 48,000 Btu/h. Model numbers are to be connected to outdoor unit heat recovery models. It shall be a four-way air distribution type, ivory white, impact resistant, and washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0 deg F to 90 deg F. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. Units shall be equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature. The indoor units sound pressure shall range from 28 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.

2. Indoor Unit:

- a. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
- b. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
- c. Both refrigerant lines shall be insulated from the outdoor unit.
- d. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
- e. The indoor units shall be equipped with a condensate pan with antibacterial treatment and condensate pump. The condensate pump provides up to 33-1/2" of lift and has a built-in safety shutoff and alarm.
- f. The indoor units shall be equipped with a return air thermistor.
- g. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
- h. The voltage range will be 253 volts maximum and 187 volts minimum.
- i. The indoor unit shall operate as single zone VAV. Airflow shall ramp up/ down based on load so as to not run the fan at full constant airflow when not needed.

3. Unit Cabinet:

- a. The cabinet shall be space saving and shall be located into the ceiling.
- b. Three auto-swing positions shall be available to choose, which include standard, draft prevention and ceiling stain prevention.
- c. The airflow of the unit shall have the ability to shut down one or two sides from the wall mounted thermostat allowing for simpler corner installation
- d. Fresh air intake shall be possible
- e. A branch duct knockout shall exist for branch ducting supply air.
- f. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

4. Fan:

- a. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with variable airflow included.
- b. The fan shall have a DC motor to further increase unit efficiency. The airflow rate shall be available in three settings from the thermostat, but shall be capable of operating as single zone VAV.
- c. The fan motor shall be thermally protected.

5. Coil:

- a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
- b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
- c. The coil shall be a 2-row cross fin copper evaporator coil with 17 FPI design completely factory tested.

- d. The refrigerant connections shall be flare connections and the condensate will be 1-1/4 inch outside diameter PVC.
 - e. A condensate pan shall be located under the coil.
 - f. A condensate pump with a 33-1/2-inch lift shall be located below the coil in the condensate pan with a built in safety alarm.
 - g. A thermistor will be located on the liquid and gas line.
6. Electrical:
- a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
 - b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
 - c. Transmission (control) wiring between the indoor and remote controller shall be a maximum distance of 1,640 feet.
7. Control:
- a. The unit shall have controls provided by the manufacturer to perform input functions necessary to operate the system.
 - b. The unit shall be compatible with connection to BMS system.
- B. 2x2 Cassette Unit:
- 1. General: Indoor unit shall be a ceiling cassette fan coil unit, operable with R-410A refrigerant, equipped with an electronic expansion valve, for installation into the ceiling cavity equipped with a decoration panel grille. It shall be available in capacities from 5,800 Btu/h to 18,000 Btu/h. The decoration panel shall be a four-way air distribution type, with fresh white, impact resistant with a washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room. The indoor units sound pressure shall range from 25.5 dB(A) to 33 dB(A) at low speed measured at 5 feet below the unit.
 - 2. Indoor Unit:
 - a. The cabinet should not overhang any of the adjacent ceiling tiles.
 - b. The decoration panel dimensions shall measure 24-7/16" x 24-7/16" and shall fit into a standard 2x2 ceiling grid with no overlap of adjacent tiles
 - c. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.
 - d. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
 - e. Both refrigerant lines shall be fully insulated from the outdoor unit or nearest branch connection into the refrigerant network.

- f. The 4-way supply air flow can be field modified to 3-way and 2-way airflow to accommodate various installation configurations including corner installations.
 - g. Return air shall be through the concentric panel, which includes a resin net mold resistant filter.
 - h. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 24-13/16" of lift, measured from the drain outlet, and has a built in safety shutoff and alarm.
 - i. The indoor units shall be equipped with a return air thermistor.
 - j. The indoor unit will be powered with 208~230V/1-phase/60Hz.
 - k. The voltage range will be 253 volts maximum and 187 volts minimum.
- 3. Unit Cabinet:
 - a. The cabinet shall be space saving and shall be located into the ceiling.
 - b. Three auto-swing positions shall be available to choose from via field setting.
 - c. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.
 - d. Fresh air intake shall be possible by way of direct duct installation to the side of the indoor unit cabinet.
 - e. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.
- 4. Fan:
 - a. The fan shall be driven by a direct-drive DC motor with statically and dynamically balanced impeller and shall have three user-selectable speeds available: high, medium, and low.
 - b. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output of 50W.
 - c. The airflow rate shall be available in high, medium, and low settings.
- 5. Filter:
 - a. The return air shall be filtered by means of a washable long-life filter with mildew proof resin.
- 6. Coil:
 - a. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
 - b. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
 - c. The coil shall be a 2-row cross fin copper evaporator coil with 22 FPI design completely factory tested.
 - d. The refrigerant connections shall be flare connections and the condensate will be 1-1/32 inch outside diameter PVC.
 - e. A condensate pan shall be located under the coil.
 - f. A condensate pump with a 24-13/16-inch lift, measured from the drain outlet, shall be located below the coil in the condensate pan with a built-in safety alarm.
 - g. A thermistor will be located on the liquid and gas line.

7. Electrical:

- a. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
- b. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
- c. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

8. Control:

- a. The unit shall have controls provided by Daikin to perform input functions necessary to operate the system.
- b. The unit shall be compatible with a Daikin Intelligent Touch Manager advanced multi-zone controller.

2.5 CONCEALED CEILING DUCTED UNIT

A. General: Indoor unit shall be a built-in ceiling concealed fan coil unit, operable with refrigerant R-410A, equipped with an electronic expansion valve, direct-drive DC (ECM) type fan with auto CFM adjustment at commissioning, for installation into the ceiling cavity. It is constructed of a galvanized steel casing. It shall be a horizontal discharge air with horizontal return air configuration. All models feature a low height cabinet making them applicable to ceiling pockets that tend to be shallow. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while limiting changes in room temperature. Included as standard equipment, a condensate drain pan and drain pump kit that pumps to 18-3/8" from the drain pipe opening. The indoor units sound pressure shall range from 29 dB(A) to 40 dB(A) at low speed measured 5 feet below the ducted unit.

B. Indoor Unit:

1. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, condensate drain pump, condensate safety shutoff and alarm, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch. The unit shall be equipped with automatically adjusting external static pressure logic that is selectable during commissioning. This adjusts the airflow based on the installed external static pressure.
2. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
3. Both refrigerant lines shall be insulated from the outdoor unit.
4. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump provides up to 18-3/8" of lift from the center of the drain outlet and has a built in safety shutoff and alarm.
5. The indoor units shall be equipped with a return air thermistor.
6. The indoor unit will be separately powered with 208~230V/1-phase/60Hz.
7. The voltage range will be 253 volts maximum and 187 volts minimum.

C. Unit Cabinet:

1. The cabinet shall be located into the ceiling and ducted to the supply and return openings.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

D. Fan:

1. The fan shall be direct-drive DC (ECM) type fan, statically and dynamically balanced impeller with three fan speeds available.
2. The unit shall be equipment with automatically adjusting external static pressure logic selectable during commissioning.
3. The fan motor shall operate on 208/230 volts, 1 phase, 60 hertz with a motor output range of 0.12 to 0.47 HP respectively.
4. The airflow rate shall be available in three settings.
5. The fan motor shall be thermally protected.
6. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.
7. Fan motor external static pressure range for nominal airflow:

E. Coil:

1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 3-row cross fin copper evaporator coil with 13 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be 1-1/4-inch outside diameter PVC.
5. A condensate pan shall be located under the coil.
6. A condensate pump with an 18-3/8-inch lift shall be located below the coil in the condensate pan with a built-in safety alarm.
7. A thermistor will be located on the liquid and gas line.

F. Electrical:

1. A separate power supply will be required of 208/230 volts, 1 phase, 60 hertz. The acceptable voltage range shall be 187 to 253 volts.
2. Transmission (control) wiring between the indoor and outdoor unit shall be a maximum of 3,280 feet (total 6,560 feet).
3. Transmission (control) wiring between the indoor unit and remote controller shall be a maximum distance of 1,640 feet.

G. Control:

1. The unit shall have controls provided by Daikin to perform input functions necessary to operate the system.
2. The unit shall be compatible with a Daikin intelligent Touch advanced multi-zone controller or an ITE Itouch customizable BMS.

2.6 CONTROLS, CONTROLS INTEGRATION, GRAPHICS PACKAGE

A. General:

1. The controls for the VR system shall be integrated with one another for a fully functioning ITE Itouch control system.
2. Control between the outdoor condensing units and the indoor fan coil units shall be achieved with the use of manufacturer's recommended cabling. This cable will form a multiplex transmission system; making it possible to connect multiple indoor fan coil units to a single outdoor condensing unit.
3. Zone controllers shall be hard-wired to a web-enabled, centralized controller that is capable of processing and managing input data from all fan coil units.
4. Centralized controllers shall have a LCD digital display and be wall-mounted.
5. The system shall be capable of scheduling groups or individual zones. The controller shall have independent cooling setup and heating setback setpoints in the unoccupied mode.
6. Auto-changover: Auto-changover shall be programmed to allow for the optimal room temperature to be maintained by automatically switching mode between Cool and Heat in accordance with the room temperature and setpoint.
 - a. The setpoint differential should adjustable between 0 deg F to 13 deg F. The (Thermal) Differential is the tolerance for the indoor unit's setpoint.
 - b. The operational mode shall change from cooling to heating when the room setpoint is exceeded by 1 deg F (adjustable).
 - c. The operational mode shall change from heating to cooling when the room temperature drops 1 deg F (adjustable) below setpoint.
 - d. A guard timer (adjustable 15-60 minutes) should be in place to prevent rapid changing, but is overridden if the room setpoint is changed.

B. Remote Access

1. Provide access to the Central Control System from a remote location, via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.
2. The system shall be capable of supporting a number of clients using a standard Web browser such as Internet Explorer.

C. Daikin ITE Supervisor Server Interface:

1. Provide a supervisor server interface that allows the District to tie all of their VRV systems district wide onto a single panel. The supervisor server provides:
 - a. Better alarm indication, management and visibility
 - b. Additional trending capabilities and trending capacity
 - c. Compare data between buildings
 - d. Much greater trending capacity
 - e. Backup data to external devices

- f. Ability to integrate with other applications for work order management and analytics packages
 - g. Mobile and remote device access.
 - h. The ability to back up systems and trending data to a central management point.
 - i. Batch provisioning of software and firmware updates
 - j. Master scheduling of devices from a central level.
 - k. Enhanced mathematical programming blocks to enable more sophisticated algorithms.
2. Shall be a server-class application with IoT (Internet of Things) software platform.
3. All other existing Daikin ITE facilities in the Jefferson City Public School District shall be networked together to provide the following:
 - a. Real time graphical information.
 - b. Centralized data logging / trend logging.
 - c. Archiving to external databases.
 - d. Master Scheduling.
 - e. Alarming.
 - f. Quickly navigate to individual buildings using tags to diagnose problems.
4. Platform requirements shall consist of:
 - a. Processor: Intel® Xeon® CPU E5-2640 x64 (or better), compatible with dual- and quad-core processors
 - b. Operating System: Windows 10, 64-bit Windows 8.1 Enterprise, 2012 R2 Standard, RHEL-7
 - c. Memory: 1 GB minimum, 4 GB or more recommended for larger systems
 - d. Hard Drive: 4 GB minimum, more recommended depending on archiving requirements
 - e. Display: Video card and monitor capable of displaying 1024 x 768 pixel resolution or greater
 - f. Network Support: Ethernet adapter (10/100 Mb with RJ-45 connector)
 - g. Connectivity: Full-time high-speed ISP connection recommended for remote site access (i.e., T1, ADSL, cable modem) and IPv6 compliant
5. Shall be configured to provide web services to any web client device such as tablets or any client desktop dependent on network security and user access and privileges.
6. Shall be supplied to allow a minimum of 10 concurrent client users without any performance degradation.

D. Zone Controllers:

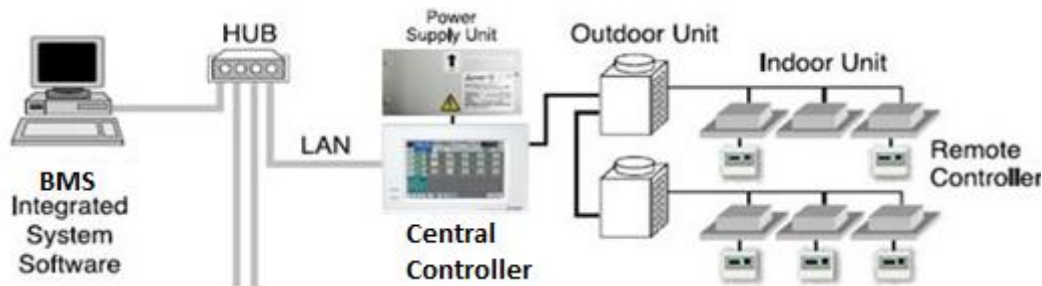
1. The Remote controller shall feature a Backlit LCD Display with contrast adjustment and auto off after 30 seconds.
2. Multiple display modes: Detailed, Standard, and Simple
3. Function button lockout (On/Off, Mode, Fan Speed, Up/Down/Left/Right Arrows)
 - a. Controller Face Plate option to hide unnecessary (locked out) buttons. Face plate and simplified display mode shall enable the user full control of the system with minimum amount of user input.

4. The following is available to display errors and to assist service personnel in troubleshooting:
 - a. A blinking LED will also signal system abnormality/error
 - b. Error codes will be displayed in the event of system abnormality/error.
 - c. Service personnel shall be able to access the following from the room controller:
 - 1) Return Air Temperature
 - 2) Liquid Line Temperature
 - 3) Gas Line Temperature
 - 4) Discharge Air Temperature (depending on unit),
 - 5) Remote Controller Sensor Temperature
 - 6) Temperature used for Indoor Unit Control
 - d. In addition to standard display mode, the thermostat must also be set up to be configured to allow for optional face plates to allow for simpler display while still having access to all service and control functions:

2.7 CONTROLS

- A. Overview: The Controls Network shall be capable of supporting remote controllers, schedule timers, system controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®.
- B. Electrical Characteristics:
 1. General: The controls network shall operate at 24VDC. Controller power and communications shall be via a common non-polar communications bus.
 2. Wiring:
 - a. Control wiring shall be installed in a daisy chain configuration from indoor unit to remote controller to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor units. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
 - b. Control wiring for schedule timers, system controllers, and centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to system controllers, to the power supply.
 - c. Control wiring for the controllers shall be from the remote controller to the first associated indoor unit then to the remaining associated indoor units in a daisy chain configuration.
 - d. A centralized controller shall be capable of being networked with all controllers for centralized on site control.
 3. Wiring type:
 - a. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire.
 - b. Network wiring shall be CAT-5e with RJ-45 connection.

- C. Controls Network: The Controls Network consists of remote controllers, schedule timers, system controllers, centralized controllers, and integrated web based interface communicating over a high-speed communication bus. The Controls Network shall support operation monitoring, scheduling, error email distribution, personal browsers, online maintenance support, and integration with Building Management Systems (BMS) BACnet® interface. The below figure illustrates a sample System Configuration.



Control Network System Configuration

D. Remote Controllers:

1. The Remote Controller shall be capable of controlling up to 16 indoor units (defined as 1 group). The Controller shall be compact in size, approximately 3" x 5" and have limited user functionality. The Controller shall allow the user to change mode (cool, heat, auto), shall provide for unoccupied/occupied override, and shall have setpoint adjustment of warmer/cooler, +/-, or similar. The Controller shall be able to limit the set temperature range from the controller, central controller or through the BMS to +/- 3 °F (adjustable). The room temperature shall be sensed at the Controller only, not at the Indoor Unit. The Controller shall display a four-digit error code in the event of system abnormality/error.
2. The Controller shall require no addressing. The Remote Controller shall connect using two-wire, stranded, non-polar control wire to a connection terminal on the indoor unit.

E. Centralized Controller:

1. Centralized Controller: The Centralized Controller shall be capable of controlling a maximum of 128 indoor units across multiple outdoor units. The Centralized Controller shall support operation superseding that of the remote controllers, system configuration, daily/weekly scheduling, monitoring of operation status, zone setpoint, setpoint range, and malfunction monitoring.
2. All Centralized Controllers shall be equipped with one Ethernet port to support interconnection with a network PC via a closed/direct Local Area Network (LAN).
3. The Centralized Controller shall be capable of performing initial settings via a high-resolution, backlit, color touch panel on the controller or via a PC using the Centralized Controller's initial setting browser.
4. Optional software functions shall be available so that the building manager can securely log into each central controller via the PC's web browser to support operation monitoring, scheduling, error email, personal browser for PCs and MACs, and online maintenance diagnostics.

F. Web-based User Interface:

1. PC-Monitoring: The control network shall be capable of monitoring and operating all indoor units from a networked PC's web browser for up to 24 units per centralized controller.
2. PC Scheduling: The control network shall be capable of creating customized daily, weekly, and annual schedules from a network PC's web browser. Schedules shall be applied to a single indoor unit, a group of indoor units, or collectively (batch) to all indoor units controlled by the central controller.
3. Online Error Email: The control network shall be capable of sending detailed alerts to customizable distribution lists based on user defined error types.
4. Personal Web Browser: The control network shall be capable of allowing up to 50 individual users to monitor and control user defined zones via a network PC or MAC's web browser.
5. Online Maintenance Diagnostics: The control network shall be capable of performing maintenance diagnostics via a network PC and centralized controller using Maintenance Tool Software.

G. Central Control Network: System Integration

1. The control network shall be capable of supporting integration with Building Management Systems (BMS) via BACnet® interface.
 - a. BACnet® Interface: The BACnet® interface, shall be compliant with BACnet® Protocol (ANSI/ASHRAE 135-2004) and be Certified by the (BTL) BACnet® Testing Laboratories. The BACnet® interface shall support a maximum of 256 devices. Operation and monitoring points include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, and error address.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install all equipment, material, accessories, etc. according to the manufacturer's instructions.
- B. Install indoor units, outdoor units, unit controllers, central controllers, accessories, and all other components per the manufacturer's installation manuals.
- C. Install units level and plumb.
- D. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- E. Install roof or ground mounted, compressor-condenser components on equipment supports as shown on the plans. Install compressor-condenser components on neoprene or other suitable vibration pads. Anchor units to supports with removable, cadmium-plated fasteners.

- F. Install and connect refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- G. Unless equipment (branch controllers and fan coils) have internal strainers, install strainers in refrigerant piping at each connection on the branch selector.
- H. Provide a permanent plastic label attached to the branch selector at each port identifying the indoor unit (by plan number) served by the port. See section 230553 - Identification for HVAC Piping and Equipment.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Where shown, drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service, maintenance, and removal of unit.
- C. Provide service valves at each refrigerant piping connection to all equipment to allow for isolation and equipment removal.
- D. Duct Connections: Duct installation requirements are specified in Section 233113 "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to indoor units with flexible duct connectors.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Remove and replace malfunctioning units and retest as specified above.
 - b. Prepare test and inspection reports.
 - 4. Complete a commissioning report by a factory authorized representative and submit to the engineer and manufacturer's Service Department.
 - 5. Refrigerant Test:

- a. To improve startup quality, a refrigerant analysis is required prior to system startup, and again during commissioning to check for the following:
 - 1) Refrigerant Impurities. A perfect blend of difluoromethane (CH_2F_2 , called R-32) and pentafluoroethane (CHF_2CF_3 , called R-125) is required. This will affect capacity and efficiency.
 - 2) Non-Condensables (0% Allowable)
 - 3) Air (0% allowable)
- b. A tested analysis outside of these guidelines will halt the commissioning process to further examine what went wrong, saving the equipment from undue damage that would have otherwise occurred.
- c. A copy of each analysis must be provided by the System manufacturer to the installing contractor and the General Contractor.
- d. Analysis must be performed by a Neutronics ULTIMA ID Refrigerant Analyzer

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units. Include up to 16 hours of onsite training and training materials for up to ten (10) trainees.

END OF SECTION 238128

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SECTION 238316 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. PEX pipe and fittings.
 - 2. Distribution manifolds.
 - 3. Piping specialties.
 - 4. Controls.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. PEX pipe and fittings.
 - 2. Distribution manifolds.
 - 3. Piping specialties.
 - 4. Controls.
- B. Shop Drawings: Show piping size, layout, and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, or Building Information Model (BIM), drawn to scale, showing the items described in this Section and coordinated with all building trades.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For radiant-heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

- A. Pipe Material: PEX plastic in accordance with ASTM F876.
- B. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) in accordance with DIN 4726.
- C. Fittings: ASTM F1807, metal insert and copper crimp rings, ASTM F1960, cold expansion fittings and reinforcing rings.
- D. Pressure/Temperature Rating: Minimum 90 psig (620 kPa) and 180 deg F (82 deg C).

2.2 DISTRIBUTION MANIFOLDS

- A. Manifold: Minimum NPS 1 (DN 25), stainless steel.
- B. Main Shutoff Valves:
 - 1. Factory installed on supply and return connections.
 - 2. Two piece body.
 - 3. Body: Brass or bronze.
 - 4. Ball: Chrome-plated bronze.
 - 5. Seals: PTFE.
 - 6. CWP Rating: 125 psig (860 kPa).
 - 7. Maximum Operating Temperature: 180 deg F (82 deg C).
- C. Manual Air Vents:
 - 1. Body: Bronze.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Key furnished with valve or screwdriver bit.
 - 4. Inlet Connection: NPS 1/2 (DN 15).
 - 5. Discharge Connection: NPS 1/8 (DN 6).
 - 6. CWP Rating: 125 psig (860 kPa).
 - 7. Maximum Operating Temperature: 180 deg F (82 deg C).
- D. Balancing Valves:
 - 1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 - 2. Ball or Plug: Brass or stainless steel.
 - 3. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - 4. Seat: PTFE.
 - 5. Differential Pressure Gauge Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 - 6. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
 - 7. CWP Rating: Minimum 125 psig (860 kPa).

8. Maximum Operating Temperature: 180 deg F (82 deg C).

E. Zone Control Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.
6. CWP Rating: Minimum 125 psig (860 kPa).
7. Maximum Operating Temperature: 180 deg F (82 deg C).

F. Thermometers:

1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, 2-inch (50-mm) diameter.
3. Element: Bimetal or other type of temperature element.
4. Movement: Mechanical, connecting element and pointer.
5. Stem: Stainless steel.
6. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
7. Pointer: Black metal.
8. Window: Plastic.
9. Connector: Rigid, back type.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

- G. Mounting Brackets: Copper, or plastic- or copper-clad steel, or stainless steel, where in contact with manifold.

2.3 PIPING SPECIALTIES

A. Cable Ties:

1. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch (3 mm).
3. Tensile Strength: 20 lb (9 kg), minimum.
4. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

B. Floor-Mounting Tracks:

1. Aluminum or plastic channel track with smooth finish and no sharp edges.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: [2-inch (50-mm)] [3-inch (75-mm)] <Insert dimension> intervals.

2.4 CONTROLS

- A. Temperature-control devices are specified in Section 230900 "Direct Digital Control (DDC) System for HVAC" and sequences of operation are on the plans.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.
- B. Install radiant-heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
- C. Connect radiant piping to manifold in a reverse-return arrangement.
- D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
- E. Install manifolds in accessible locations or install access panels to provide maintenance access as required.
- F. Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties" for pipes and connections to hydronic systems.
- G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials in accordance with Section 078413 "Penetration Firestopping."
- H. Piping in Interior Concrete Floors:
 - 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - 2. Space cable ties at maximum spacing recommended by the manufacturer and at center of turns or bends.
 - 3. Maintain minimum cover recommended by the manufacturer.
 - 4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - 5. Maintain minimum 40 psig (275 kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

3.2 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

1. Prepare radiant-heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water and clean strainers.
2. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - a. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig . Repair leaks and retest until no leaks exist.
 - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Protect hydronic piping system from damage during construction.

END OF SECTION 238316

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SECTION 260500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Fire Rated Sleeves for cables.
 - 4. Grout.
 - 5. Common electrical installation requirements.
 - 6. Utility company coordination requirements.

1.3 DEFINITIONS

- A. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- B. "Install": Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.
- C. "Provide": Furnish and install, complete and ready for the intended use.

1.4 ACTION SUBMITTALS

- A. Product Data: For Fire Rated Sleeves for cables.

1.5 INFORMATION SUBMITTALS

- A. Coordination Drawings

- 1. Provide coordinated layout drawings (composite drawings), prior to commencing site work. Coordinate with trades on the site such as but not limited to HVAC, Plumbing, Electrical, Technologies, Civil, Landscape, Cabinetry, Roofing, Finishes, Fire Protection, and Fire detection.
 - 2. Coordination drawings shall include information furnished by trades Coordinate installation and location of but not limited to the following elements and trades: Civil,

- Landscape, HVAC, Plumbing, Fire Protection, Electrical, Technology Systems, Architectural, Structural, and Specialty Systems.
3. Coordinate with architectural system submittals (i.e. roofing, ceilings, finishes, cabinetry) and structural system submittals, including footings and foundation. Identify zone of influence from footings and ensure systems are not routed within the zone of influence.
 4. Provide and indicate required maintenance access to equipment and maintain the clearances per manufacturer's and applicable code requirements.
 5. Prepare Drawings in Revit Model as follows:
 - a. Utilize Revit Model release equal to design documents.
 - b. Drawings to be same sheet size and scale as Contract Drawings.
 - c. Indicate location, size and elevation above finished floor of equipment and distribution systems.
 - d. Incorporate Addenda items and change orders.
 6. Advise Architect in the event conflict occurs. Bear costs resulting from failure to properly coordinate installation or failure to advise Architect of conflict.
 7. Submit final Coordination Drawings with changes as Record Drawings at completion of project.

1.6 COORDINATION

- A. Trade Coordination: Include physical characteristics, electrical characteristics, device layout plans, wiring diagrams, and connections. For equipment with electrical connections, furnish copy of approved submittal for inclusion in Division 26, Electrical submittal.
- B. Location of electrical outlets and equipment:
 1. Location of electrical outlets and equipment shown on electrical drawings are diagrammatic. Unless indicated otherwise do not use electrical drawings to locate electrical outlets and equipment.
 2. Luminaires and outlets:
 - a. Ceiling mounted luminaires and outlets: Use architectural reflected ceiling plans and details to determine location unless indicated otherwise.
 - b. Wall mounted luminaires and outlets:
 - 1) Use architectural elevation and section drawings to determine location unless indicated otherwise.
 - 2) Where architectural elevation and section drawings do not indicate location of wall outlets then locate the outlet within 12 inches of location shown on electrical drawings considering field conditions.
 - 3) Coordinate location with consideration of Owner provided equipment such as wall mounted televisions, white boards, furniture, cabinets and the like.
 - c. Floor boxes and poke-thru assemblies: Obtain dimensioned locations from Owner.
 - d. Cabinet mounted luminaires and outlets: Use cabinet details and shop drawings to determine location unless indicated otherwise.

- e. Exterior luminaire poles and bollards: Use locations indicated on civil plans and landscape plans unless indicated otherwise.
 - f. Landscape luminaires: Use locations indicated on landscape drawings unless indicated otherwise.
 - g. Kitchen Equipment outlets: Use location indicated on kitchen drawings unless indicated otherwise.
 - 3. Electrical equipment: Utilize approved manufacturer's shop drawing dimensions to determine location of equipment in space. Comply with NEC 110.26 access, working space and dedicated equipment space requirements. Maintain manufacturer requirements for maintenance access.
 - 4. Owner-furnished equipment: use location shown on architecture plans unless indicated otherwise.
 - 5. Electrical handholes and manholes: use location shown on civil plans unless indicated otherwise.
 - 6. Outdoor Electrical equipment: use location shown on civil plans unless indicated otherwise.
- C. Shop Drawings: Provide coordinated shop drawings which include physical characteristics of all systems, device layout plans, and control wiring diagrams. Reference individual Division 26, Electrical specification sections for additional requirements for shop drawings outside of these requirements.
- D. Electrical connections to equipment supplied by Owner or other trades:
- 1. Prior to procurement of electrical equipment and field work coordinate with shop drawings and/or manufacturer's installation instructions the actual electrical characteristics of the equipment to be connected.
 - 2. Notify Engineers of significant deviations or conflicts between the shop drawings and/or the manufacturer's installation instructions and information in the contract documents.
- E. 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 so connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- F. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- G. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- H. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

- I. Coordinate and install wiring for appliances and systems furnished under other specification Divisions or furnished by the Owner. Install electrical wiring in accordance with manufacturer's instructions.:
 - 1. Motorized door operators.
 - 2. Kitchen equipment, including walk-in freezer and coolers.
 - 3. Electric water coolers.
 - 4. Medical equipment such as x-ray equipment, CT scanners, MRI scanner,
 - 5. Fabrication shop equipment.
 - 6. Exterior signage.
 - 7. Owner-provided equipment.

1.7 SERVING UTILITY COMPANIES.

- A. Construction drawings indicate approximate locations and routing. Coordinate exact placement of transformers, vaults, raceway, pads, poles, enclosures, and other equipment with the serving utility companies and civil plans. Comply with serving utility requirements for clearances, access, materials, workmanship, separation from other utilities, and other documented requirements.
- B. Coordinate with the serving utility companies, including but not limited to the Power Company and Internet Company. Verify the extent of work to be performed by the utility companies. Provide labor and materials not provided by the serving utility companies that is required for a complete and operational system.
- C. Refer to civil drawings for contact information.
- D. Coordinate detailed requirements and construction schedule with serving utility companies prior to procurement of materials and work on the site.
- E. Provide detailed shop drawing illustrating routing of conduits, layout of equipment, location of adjacent utilities, structures, landscape elements, and architectural features. Obtain approval of the shop drawings from serving utility company prior to work on the site and procurement of material.

1.8 PERMITS AND FEES

- A. Owner will pay all charges and/or fees levied by the serving utility companies relative to this project.
- B. Obtain and pay all fees for permits, licensing, and inspections applicable to work of Division 26 27 and 28.

1.9 QUALITY ASSURANCE

- A. Regulatory Requirements: Install work and materials to conform with local, State and Federal codes, and other applicable laws and regulations.

- B. Drawings are intended to be diagrammatic and reflect the Basis of Design manufacturer's equipment. Drawings are not intended to show every item in its exact location, or details of equipment or proposed systems layout. Verify actual dimensions of systems (i.e. distribution equipment, duct banks, light fixtures, etc.) and equipment proposed to assure that systems and equipment will fit in available space. Contractor is responsible for design and construction costs incurred for equipment other than Basis of Design, including, but not limited to, architectural, structural, electrical, HVAC, fire sprinkler, and plumbing systems.
- C. Manufacturer's Instructions: Follow manufacturer's written instructions. If in conflict with Contract Documents, obtain clarification. Notify Engineer/Architect, in writing, before starting work.
- D. Items shown on Drawings are not necessarily included in Specifications or vice versa. Confirm requirements in all Contract Documents. 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. Provide Qualified Personnel that are thoroughly knowledgeable of applicable codes related to electrical systems to perform the electrical work. Installations shall be performed by skilled electrical tradesmen fully aware of the latest techniques, practices, and standards of the industry. Refer to N.E.C. Article 100-Definitions, Qualified Person.
- F. Install electrical equipment and components in a neat and workmanlike manner in accordance with recognized practices and industry standards. Refer to N.E.C.110-12. Haphazard or poor installation practice will be cause for rejection of the work.
- G. Trenching: Arrange for all trenched conduit to be inspected by the utility for which they are intended prior to backfill.

PART 2 - PRODUCTS

2.1 SUBSTITUTION LIMITATIONS FOR ELECTRICAL EQUIPMENT

- A. Substitution requests for electrical equipment will be entertained under the following conditions:
 - 1. Substitution requests may be submitted for consideration prior to the Electrical Preconstruction Conference if accompanied by value analysis data indicating that substitution will comply with Project performance requirements while significantly increasing value for Owner throughout life of facility.
 - 2. Substitution requests may be submitted for consideration concurrently with submission of power system study reports when those reports indicate that substitution is necessary for safety of maintenance personnel and facility occupants.
 - 3. The contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

- B. Substitution and Variation from Basis of Design: The Basis of Design designated product establishes the qualities and characteristics for the evaluation of any comparable products by other listed acceptable manufacturers if included in this Specification or included in an approved Substitution Request as judged by the Design Professional.
- C. Proposed Substitutions: If substitutions are proposed, it is the responsibility of parties concerned, involved in, and furnishing the substitute and/or equivalent equipment to verify and compare the characteristics and requirements of that furnished to that specified and/or shown. If greater capacity and/or more materials and/or more labor is required for the rough-in, circuitry or connections than for the item specified and provided for, then provide compensation for additional charges required for the proper rough-in, circuitry and connections for the equipment being furnished. No additional charges above the Base Bid, including resulting charges for work performed under other Divisions, will be allowed for such revisions. Coordinate with the requirements of "Submittals". For any product marked "or approved equivalent", a substitution request must be submitted to the Engineer for approval prior to purchase, delivery or installation.

2.2 SLEEVES FOR RACEWAYS AND CABLES

- A. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.
- 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).
- C. EMT: Electrical Metallic Tubing.
- D. PVC: Schedule 40 or 80.
- E. Fiberglass.

2.3 FIRE RATED SLEEVES FOR CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M
 - 2. Hilti
 - 3. Specified Technologies, Inc (STI)
 - 4. Wiremold.

- B. Factory assembled rectangular steel pathway containing an intumescent insert material that adjusts automatically to cable addition or subtraction.
- C. Sleeve shall have an F Rating equal to or greater than the rating of the wall in which the sleeve is installed.
- D. Sleeve shall be UL listed and bear the UL Classification marking.
- E. Sleeve shall be tested in accordance with ASTM E814 (ANSI/UL1479).
- F. Provide square wall plate kits for single sleeve applications. Provide multi-gang wall/floor plate kits for ganged applications.
- G. 8-Inch Walls (or less): Subject to compatibility with requirements and field conditions, i.e. sleeve size, wall thickness, etc., acceptable products include the following:
 - 1. Hilti Speed Sleeves, 4-inch.
 - 2. Specified Technologies Inc. EZ-Path Fire Rated Pathway (series 44).
 - 3. Wiremold Flamestopper FS4 Series. Conduit sleeve provided separately.
- H. Walls Systems Greater than 8-Inch Thickness: Subject to compatibility with requirements and field conditions, i.e. sleeve size, wall thickness, etc., acceptable products include the following, or approved equal:
 - 1. Wiremold Flamestopper FS4 Series. Conduit sleeve provided separately.

2.4 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 INSTALLATION OF ELECTRICAL WORK

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.
- B. Comply with NECA 1.
- C. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- D. 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.

- E. 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.
- F. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete, masonry and gypsum board walls, or fire-rated floor and wall assemblies.
- B. Sleeves are required where cables (not in raceway) penetrate walls or floors. Sleeves are not required where raceways penetrate walls, except where raceways penetrate exterior walls/foundations below grade.
- C. Concrete Slabs and Walls: Install sleeves during erection of slabs and walls.
- D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- E. 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.
- F. Provide insulated bushings on EMT sleeves for cable not in conduit. Bushings shall be plenum rated where installed in a plenum.
- G. Extend sleeves installed in floors 4 inches (100 mm) above finished floor level unless noted otherwise.
- H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- I. 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.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

- L. Underground, Exterior-Wall Penetrations: Install cast-iron pipe or PVC, schedule 40 or 80, sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve. Cut sleeves to length for mounting flush with both surfaces of walls.
- M. Fire Rated Sleeves for cables: Fabricate openings in wall or floor assemblies per manufacturer's recommendations.

3.3 SLEEVE APPLICATION

- A. Sleeves for cables not in conduit:
 - 1. Through Non-Rated Interior Walls: EMT sleeves.
 - 2. Through Non-Rated Floors: EMT sleeves.
 - 3. Through Fire Rated Interior Walls: Fire Rated Sleeves for cables.
 - 4. Through Fire Rated Floors: Fire Rated Sleeves for cables.
- B. Sleeves for conduits:
 - 1. Through Exterior Walls Below Grade: Refer to details on structural Drawings. Absent any such details provide cast iron pipe or PVC, Schedule 40 or 80, sleeve two trade sizes larger than the conduit.
- C. Sleeves for Cable Trays:
 - 1. Through Non-Rated Interior Walls: In CMU walls, coordinate with other trades to provide half or whole block opening, depending on tray size. In GWB walls, coordinate GWB trimmed rectangular opening with other trades.
 - 2. Through Fire Rated Walls: Stop cable tray 6 inches maximum for each side of wall and provide multiple fire rated sleeves for cables with combined allowable area for cable equal to the capacity of the cable tray unless noted otherwise.

3.4 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 260500

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SECTION 260503 – DEMOLITION OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes:
 - 1. Demolition and removal of selected portion of electrical systems, including special systems normally specified in Division 28.
 - 2. Salvage of existing items to be reused.
 - 3. Salvage of existing items to be delivered to the Owner.

1.3 DEFINITIONS

- A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated to be removed and salvaged or removed and reinstalled.
- B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and deliver to Owner.
- C. Remove and Reinstall: Detach items from existing construction, prepare for reuse, and reinstall where indicated.
- D. Existing to Remain: Existing items of construction that are not to be permanently removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 MATERIALS OWNERSHIP

- A. Unless otherwise indicated, demolition waste becomes property of Contractor.
- B. Remove and salvage items noted as 'salvage', 'return to Owner' or similar manner on the Drawings.
- C. Remove and salvage items as requested by the Owner. Conduct a meeting with the Owner prior to commencing demolition to determine items that the Owner wishes to retain.

1.5 PRE-TESTING

- A. Existing Branch Circuits that Remain: Trace and ring-out existing branch circuits. Update panel schedules and relabel outlets, disconnect switches, boxes, and the like with actual branch circuit designations. Include such information in record drawings.
- B. Prepare a typed written report documenting any items found to be damaged or in a non-working condition. Submit report to the Owner and Architect prior to commencing work. All devices and systems shall be considered in good working conditions if a report is not submitted and acknowledged by the Owner prior to commencing work.
- C. Arrange a time to perform testing with the Owner with at least two weeks advanced notice.
- D. Include testing reports for above in closeout documentation. Record measurements and actions taken.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 ELECTRICAL SYSTEMS DEMOLITION

- A. Remove items depicted or denoted for demolition on the Drawings. Unless noted otherwise, removal of the items shall include devices, boxes, cable, supporting elements, raceway, etc. associated with the item back to the panelboard or nearest j-box or device to remain.
- B. Drawings are intended to indicate the general scope of demolition work. Visit the Project site to verify existing conditions prior to bidding. Determine means and methods for performing work. Identify existing building finishes, ceiling types, access, and fire walls. Determine locations, routings, and distances as necessary. Coordinate with the Owner to gain access to the facility.
 - 1. Wherever walls, ceilings, structures, or electric-powered equipment are indicated as being removed on the Drawings (including architectural demolition plans and mechanical demolition plans) remove associated electrical system components, equipment, devices, fixtures, raceways, and wiring. Remove, relocate, and extend existing installations, as necessary, to accommodate demolition work, new work, and to maintain the existing electrical installations that shall remain operational. Repair adjacent construction and finishes damaged during demolition and extension work. Patch openings to match existing surrounding finishes.
 - 2. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
 - 3. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

- C. Verify that abandoned wiring and equipment serve only abandoned equipment or facilities. Extend conduit and wire to loads that remain in operation (i.e., facilities, luminaires, wiring devices, equipment, etc.). Extension of conduit and wire to equipment shall be compatible with the surrounding area.
 - 1. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel and/or junction boxes where appropriate.
 - 2. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces. Remove all associated clamps, hangers, supports, etc. associated with raceway removal.
- D. Where existing conduits and/or cables, which remain in service, pass through areas to be renovated and where such conduits and/or cables interfere with new work, reroute these conduits and/or cables to avoid new construction. Provide necessary boxes, cables, splicing and fittings for the rerouting of the circuits. Field-verify to determine complete scope of work prior to bidding.
- E. Existing conduit may remain if all the following are true:
 - 1. Conduit will be reused to feed items installed under this contract.
 - 2. Conduit does not interfere with other trades.
 - 3. Conduit was originally installed meeting specifications related to this project.
 - 4. Conduit will not be exposed in a finished area (unless noted otherwise).
- F. Provide plugs on boxes to remain where conduits have been removed.
- G. Conduits concealed in masonry walls or under concrete slabs may be cut back, sealed and abandoned.
- H. Provide blank cover-plates on all abandoned boxes to remain in existing masonry or stud walls. Plate color and material shall match wiring devices plates specified for the project. In the absence of such specification, match the color and material of existing wiring devices in the area.
- I. Maintain power to end-of-line or downstream devices to remain. Provide raceways, boxes, conductors and all other necessary materials as required to re-establish damaged or interrupted feeders and branch circuits. Intercept existing feeders or branch circuits at nearest accessible space or device and reconnect to original feeder or branch circuit source.
- J. Repair or replace ceilings, ceiling tiles, and ceiling-grids that are damaged by this contractor.
- K. Electrical installations that remain shall be concealed, unless otherwise indicated or unless located within unfinished utility-type spaces. Cut and patch existing walls and ceilings as required. Exposed conduits and raceways will be rejected, unless prior approval has been obtained. Confirm scope of work and specific requirements for all such work directly with the Owner and the Architect.
- L. Prior to drilling existing precast concrete walls, detect and locate existing structural members imbedded within the precast panels to ensure they are not damaged.

3.2 REMOVED MATERIALS

- A. Existing wiring and transformers removed shall be regarded as scrap materials to be recycled by this contractor. Scrap value shall be determined by the contractor and accounted for in the contractor's bid.
 - 1. All other demolished electrical items (e.g., power panels, luminaires, receptacles, switches, controllers, system devices, etc.) shall be regarded as the Owner's property. The Owner reserves the right to identify which items shall be salvaged—and, thus, carefully removed by this contractor and placed in storage on site as directed by the Owner. The contractor shall be responsible for the proper disposal of all demolished materials that the Owner does not want to salvage. Coordinate specific requirements directly with Owner.

END OF SECTION 260503

SECTION 260519 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Aluminum building wire rated 600 V or less.
3. Metal-clad cable, Type MC, rated 600 V or less.
4. Cord Products.
5. Connectors, splices, and terminations rated 600 V or less.

- B. Related Requirements:

1. Section 260533 "Raceway and Boxes for Electrical Systems" for allowable applications of raceways and cable assemblies. Cable assemblies, such as Type MC cable, shall not be permitted unless noted otherwise.
2. Section 260553 "Identification for Electrical Systems" for conductor color coding.

1.3 DEFINITIONS

- A. PV: Photovoltaic.
- B. RoHS: Restriction of Hazardous Substances.
- C. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTAL

- A. Field quality-control reports.

1.6 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.

PART 2 - PRODUCTS

2.1 BUILDING WIRE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alan Wire Company
 - 2. Cerro Wire
 - 3. CME Wire and Cable
 - 4. Encore Wire Corporation
 - 5. General Cable.
 - 6. Houston Wire & Cable Company.
 - 7. Okonite Company (The)
 - 8. Southwire Company.
- B. Copper Building Wire:
 - 1. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
 - 2. Conductors: complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.
- C. Aluminum Building Wire:
 - 1. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
 - 2. Conductors: 8000 series electrical grade aluminum alloy, complying with ASTM B800 and ASTM B801.
 - 3. Permitted for feeders over 100 amps only.
 - 4. Aluminum building wire shall not be used for connections to any equipment that has not been used UL tested with aluminum building wire connections or where such connection will void or reduce the manufacturer's warranty. Such equipment includes, but is not limited to, HVAC equipment and elevators.
- D. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.

3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

E. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

F. Temperature Ratings: All conductors shall be rated 75-degree C minimum.

2.2 METAL-CLAD CABLE, TYPE MC

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

1. AFC Cable Systems, a part of Atkore International
2. Alan Wire Company
3. Belden
4. CME Wire and Cable
5. Encore Wire Corporation
6. General Cable.
7. Houston Wire & Cable Company
8. Okonite Company (The)

B. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. RoHS compliant.
4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

D. Circuits: Single circuit with color coded conductors. Separate neutral conductors shall be included for each circuit originating from a unique overcurrent protection device.

E. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

F. Ground Conductor: Insulated.

G. Conductor Insulation:

1. Type TFN/THHN/THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

- H. Armor: Steel or aluminum, interlocked
- I. Jacket (optional): PVC applied over armor.

2.3 CORD PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Southwire.
- B. Description: Flexible, hard-use service cord with black rubber jacket. Type SO, SOW, etc.
- C. Circuits: Single circuit and multi-circuit with color coded conductors. Separate neutral conductors shall be included for each circuit originating from a unique overcurrent protection device.
- D. Conductors: Copper, complying with ASTM B8 for stranded conductors.
- E. Ground Conductor: Insulated.
- F. Conductor Insulation:
 - 1. Type THHN/THWN-2: Comply with UL 83.

2.4 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. 3M Electrical Products
 - 2. AFC Cable Systems, a part of Atkore International
 - 3. Appleton, a brand of Emerson
 - 4. Gardner Bender
 - 5. Hubbell Power Systems
 - 6. Ideal Industries, Inc
 - 7. IlSCO
 - 8. Neer, a brand of Emerson
 - 9. NSI Industries
 - 10. O-Z Gedney, a brand of Emerson
 - 11. Thomas & Betts Corporation
- B. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Lugs for attachment to telecommunications systems grounding busbars shall be two-hole with long barrels and irreversible crimp terminations.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
 - 1. 100 Amps and Less: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 - 2. Over 100 amps: Copper or aluminum, stranded.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
- B. Feeders to Distribution Equipment and Panelboards: Type XHHW-2, single conductors in raceway.
- C. Exterior Feeders and Branch Circuits Routed Horizontally on Roofs: Type XHHW-2, single conductors in raceway.
- D. Other Feeders and Branch Circuits: Type THHN-THWN, single conductors in raceway.
- E. Feeders connected from the load-side of VFDs to electric motors: Type XHHW-2 single conductors installed in a raceway or Type XHHW-2 MC cable where permitted.
- F. Conductors serving circuits downstream of a device with GFCI or GFP protection shall have XHHW-2 insulation.
- G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.
- H. Metal Clad Cable
 - 1. Uses permitted:
 - a. Branch circuits rated less than 50 amps.
 - b. In areas that have accessible ceiling space.
 - c. Fixture whips: Maximum of 72-inches between junction and luminaire or disconnect.

- d. Connections between luminaires above accessible ceilings. Provide Caddy clips at light fixture support wires where structure is not available. Fastening to ceiling support wires is not permitted.
 - e. Between device boxes in stud walls.
 - f. From concealed wall boxes to boxes above accessible ceilings. Provide in-wall transition to EMT from concealed wall boxes out into exposed structure or where ceilings do not extend to walls.
 - g. Between boxes in rooms above accessible ceilings.
2. Uses not permitted:
- a. Feeders.
 - b. Homeruns.
 - c. Inaccessible ceiling spaces.
 - d. Areas that have no ceiling or exposed structure where ceiling systems do not extend to walls.
 - e. Room-to-room or room-to-corridor. Branch circuits in all spaces shall originate at a junction box fed via EMT.
 - f. Corridors and hallways, other than fixture whips.
 - g. Exposed raceway.
 - h. Wet or damp locations.

3.3 CONDUCTOR SIZES

- A. Minimum Wire Size (Interior Work): No. 12 AWG, except No. 14 AWG shall be permitted for signal, pilot control circuits and fixture whips.
- B. Minimum Wire Size (Exterior Work): No 10 AWG.
- C. Use #10 AWG minimum conductor size in lieu of #12 AWG minimum for 20 ampere, 120 volt branch circuits where homeruns are longer than 75 feet and for 20 ampere, 277 volt branch circuits where homeruns are longer than 175 feet. Increase in size as required for a maximum of 3 percent voltage drop from panel to load.
- D. Derate conductors based on quantity of current carrying conductors in each conduit. Refer to the NEC for derating factors.
- E. Derate conductors for high ambient temperatures. Refer to the NEC for derating factors.

3.4 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- E. Install exposed cables and concealed Type MC cable parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
 - 1. Type MC Cable: Securely fasten to walls or structural members at intervals not to exceed 48-inches. Securely fasten within 12-inches of each box or other cable termination. Unsupported cable or cable fastened to ceiling support wires or other system supports shall not be permitted. All boxes shall be mechanically fastened to rigid structure.
 - 2. Fasteners: Metallic straps or j-hooks at walls. Beam clamps, conduit clamps, j-hooks or bridle rings at structural members. Cable ties shall not be permitted.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- G. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- H. Branch circuits serving receptacles and lighting loads shall have dedicated neutral conductors and shall not share a common neutral conductor. The use of handle ties across single pole circuit breakers to allow the use of a common neutral is not acceptable.
- I. Derating factors shall be applied, per NEC Article 310, to multiple current-carrying conductors installed within the same conduit. Neutral conductors shall be regarded as current-carrying conductors. Wire sizes shall be increased as needed to maintain the ampacity that corresponds to the overcurrent protection device rating.

3.5 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- 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 (150 mm) of slack.

3.6 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors 100 amps and larger for compliance with requirements:
 - 2. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
 - g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.
 - 4. Submit reports only if requested.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment.
- B. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Ground bonding common with lightning protection system.

1.3 ACTION SUBMITTALS

- A. Product Data: Submit for each type of product indicated in this section.
- B. Photographic evidence of underground electrode installation.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans showing dimensioned locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Ground rods.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For grounding 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. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - 1) Ground rods.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.2 ELECTRICAL GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Chatsworth.
 2. Cooper B-Line.
 3. Erico.
 4. Harger.
 5. Panduit.
- B. Products shall be UL listed.
- C. Copper busbar, 0.25-inch thick minimum, insulated stand-offs, factory predrilled standard size holes.
- D. Electrical Grounding Busbars: Height shall be 4-inches minimum and length shall be 24-inches minimum unless indicated otherwise on Drawings. Erico EGB series or equal.
- E. Connector Lugs: Lugs for connecting to grounding electrode conductors and bonding conductors shall be UL listed two-hole, long barrel, electro tinplated compression lugs.

2.3 TELECOMMUNICATIONS GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Chatsworth.
 2. Cooper B-Line.
 3. Erico.
 4. Harger.
 5. Legrand Ortronics.
 6. Panduit.

- B. Products shall be UL listed meet the specification of TIA/EIA 607 and conform to BICSI recommendations.
- C. Copper busbar, 0.25-inch thick minimum, insulated stand-offs, factory predrilled standard size holes per TIA/EIA 607 standard.
- D. Telecommunications Main Grounding Busbars: Height shall be 4-inches. Length shall be 20-inches minimum unless indicated otherwise on Drawings. Chatsworth 40153 series or equal.
- E. Telecommunications Grounding Busbars: Height shall be 2-inches. Length shall be 10-inches minimum unless indicated otherwise on Drawings. Chatsworth 13622 series or equal.
- F. Connector Lugs: Lugs for connecting to telecommunications grounding busbars shall be UL listed two-hole, long barrel, electro tinplated compression lugs.

2.4 CONDUCTORS

- A. Insulated Conductors: Tinned-copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM 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, 1/4 inch (6 mm) 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 (41 mm) wide and 1/16 inch (1.6 mm) thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.5 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.

- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with zinc-plated or stainless-steel bolts.
 - a. Material: Tin-plated aluminum.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

2.6 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel, sectional type; 3/4 inch by 10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 30 inches (600 mm) below grade.
- C. Grounding Conductors: Green-colored insulation with continuous yellow stripe.
- D. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors or listed irreversible crimp, except as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors
 - 4. Connections to Structural Steel: Bolted connectors where connection can be inspected after project completion. Welded connectors where connection will be concealed and not accessible upon project completion.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Provide grounding as required by the serving utility company. Grounding shall be provided at, but not limited to, the following locations:
 - 1. Transformer.
 - 2. Meter.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.5 TELECOMMUNICATIONS GROUNDING

- A. Provide grounding in accordance with EIA/TIA 607 and as indicated on Drawings.

3.6 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

- C. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
 - 2. Use exothermic welds for all below-grade connections.
 - 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- 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.
- E. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, 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 aboveground portion of gas piping system downstream from equipment shutoff valve.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
 - 1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 - 2. Bury ground ring not less than 24 inches (600 mm) from building's foundation.
- H. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 copper size AWG.
 - 1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.

2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.
- I. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.7 FIELD QUALITY CONTROL

- A. Prior to covering underground UFER grounds and connections to ground rods, take digital photographs of the grounding electrodes including conductor connections. Record locations of each photograph. Submit to A/E for documentation purposes.
- B. 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. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 4. Prepare dimensioned drawings locating each ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system will be considered defective if it does not pass tests and inspections.

- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
 - 3. Substations and Pad-Mounted Equipment: 5 ohms.
 - 4. Manhole Grounds: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 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 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. RMC: Rigid metal conduit.

1.4 SUBMITTALS

- A. Product data for the following:
 - 1. J-Hooks
 - 2. Bridle Rings

1.5 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported system and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

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 products 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. PW Industries.
 - f. Thomas & Betts Corporation.
 - g. Unistrut; Tyco International, Ltd.
 - h. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. 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 Hangers, clamps, j-hooks, bridle rings, cable ties and associated fittings, designed for types and sizes of raceway or cable to be supported.
 - 1. J-Hooks: Metallic hooks with smooth beveled edges and bendable cable retainage locking tabs.
 - a. Erico Caddy J-hook CAT Link System or approved equal.
 - 2. Bridle Rings: Zinc-plated steel construction with machine-threaded end and open slot ring.
 - 3. Cable Ties: Nylon construction, UL 94V-2 Flame Rating.
- 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. Support for conduits routed horizontally on roofs: Factory assembled UV-stabilized rubber base with galvanized steel channel for attachment of conduit(s). Size and type of support as recommended by manufacturer for the quantity and weight of conduits supported. Provide one of the following products:
 - 1. Cooper B-Line Dura-Blok Rooftop supports
 - 2. Erico Caddy Pyramid Rooftop Supports
 - 3. Miro Industries Inc. Conduit Supports
 - 4. RoofTop Accessories Curb Supports
- G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of 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.
 - 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 - 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 - 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

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. Outdoor Equipment Support: Galvanized strut and mechanical fasteners for support of all ground-mounted and rooftop equipment.
- C. Materials: Comply with requirements in Division 05 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. Low Voltage Cable Supports: Cable tray shall be limited to telecom and intercom systems cabling only, including PoE access control and video surveillance cabling. J-Hooks and bridle rings shall support other system cabling as follows:
 1. Fire alarm cable shall utilize independent, dedicated j-hooks and bridle rings.
 2. Lighting control and HVAC control cabling shall be allowed to share J-Hooks and bridle rings.
 3. J-Hooks shall be allowed to be fastened along cable tray sidewalls where available.
 4. Where ceilings are not continuous to walls, J-Hooks shall be suspended from thread rod or fastened to structure above ceiling system and shall not be allowed to run along walls where visible from below. Refer to Drawings for corridor ceiling conditions.
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.

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 RMC 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 (90 kg).
- 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. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 - 6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. 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 05 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 (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 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. 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 (0.05 mm).
- B. Touchup: Comply with requirements in Division 09 Painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAY 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. GRC: Galvanized rigid conduit.
- F. HDPE: High Density Polyethylene.
- G. IMC: Intermediate metal conduit.
- H. LFMC: Liquidtight flexible metal conduit.
- I. LFNC: Liquidtight flexible nonmetallic conduit.
- J. NBR: Acrylonitrile-butadiene rubber.
- K. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: Product data for the following:
 - 1. Exterior exposed GRC or IMC raceway.
 - 2. Exterior cast metal device box (rooftops, renovation).
 - 3. Underground raceway.

4. Handholes, including structural rating and molded lettering cover configurations for each application.
5. PVC coated rigid steel conduit, or galvanized rigid steel conduit with overlapping corrosion protection tape.
6. Interior EMT raceway and fittings.
7. Surface metal raceways and boxes (renovation only).
8. Lighting and door hardware controls enclosures.
9. Floor boxes, including box, finished metallic covers, protective blanking plate or concrete cover, and device inserts for each device type, including unused openings.
10. Poke-thru devices, finished metallic covers, protective blanking plate or concrete cover, and device inserts for each device type, including unused openings.
11. Plenum-rated bushings.

1.5 COORDINATION

- A. Install all exposed raceway, boxes and covers in finished areas with painted exposed structure prior to paint application. Does not apply to pre-finished surface metal raceway.

1.6 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.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AFC Cable Systems, Inc., a Tyco International Ltd. Co.
 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 3. Anamet Electrical, Inc.; Anaconda Metal Hose.
 4. Calbond
 5. Calbrite
 6. Electri-Flex Co.
 7. O-Z Gedney; a brand of EGS Electrical Group
 8. Republic Conduit
 9. Southwire
 10. Western Tube & Conduit Corporation
 11. Wheatland Tube Company
- B. Rigid Steel Conduit: ANSI C80.1.

- C. IMC: ANSI C80.6.
- D. PVC-Coated Steel Conduit:
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch, minimum.
- E. Corrosion Protection Tape: PVC-based tape with high tack adhesive formulated to resist corrosion of electrical conduit systems.
 - 1. Tape width per manufacturer's recommendation based on minimum 1/2-inch overlap.
 - 2. Thickness: 10mil.
 - 3. Pipe primer applied per manufacturer's recommendation.
 - 4. 3M Scotchrap Tape 50, or approved equal.
- F. EMT: ANSI C80.3.
- G. FMC: Zinc-coated steel
- H. LFMC: Flexible steel conduit with PVC jacket.
- I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: 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 compression type.
 - 2. Conduit bushings: Plenum-rated, press on insulating type.
 - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.
 - 4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Allied
 - 2. Calbond.
 - 3. CANTEX Inc
 - 4. FRE Composites/Atkore
 - 5. Lamson & Sessions; Carlon Electrical Products.
 - 6. RACO; a Hubbell Company.
 - 7. Thomas & Betts Corporation.
- B. Fiberglass: E or E-CR glass roving encapsulated in corrosion-resistant epoxy resin, UV inhibiting pigment, UL 94 HB rated, UL 2420 listed.
- C. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

- D. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.
- E. HDPE: NEMA TC 7, Type EPEC 40, UL 651B listed, NEC compliant, smoothwall coilable PE Electrical Plastic Conduit.

2.3 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products 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.
- 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. Wireway Covers: Screw-cover type.
- E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS – RENOVATION ONLY

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hubbell.
 - b. Mono-Systems Inc.
 - c. Wiremold Company (The); Legrand
 - 2. Power: Wiremold V500 Series or approved equal.
 - 3. Communications: Wiremold V2000 Series, or approved equal.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Adalet; a division of Scott Fetzer Co.
 - 2. Appleton Electric, a brand of EGS Electrical Group
 - 3. Calbond

4. Calbrite
5. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
6. Hoffman.
7. Killark Electric Manufacturing Co; a Hubbell Company
8. Lew Electric Floor Box and Fittings Company
9. O-Z Gedney; a brand of EGS Electrical Group
10. RACO; a Hubbell Company.
11. Spring City Electrical Manufacturing Company.
12. Stahlin; a division of Robroy Industries
13. Steel City; Thomas & Betts Corporation.
14. Wiremold Company (The); Legrand.

- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover, minimum 2.5-inch depth.
- D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- E. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- F. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
- G. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Accessory feet where required for freestanding equipment.
- H. Lighting and Door Hardware Controls Enclosures:
1. For lighting and door hardware controls in areas of painted exposed structure, provide side-hinged white NEMA 1 enclosure with side knockouts and latch or friction dimple with pull ring.
 - a. Cooper B-Line HC series, or approved equal. Size as required.

2.6 FLOOR BOXES AND POKE-THRU

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

1. Wiremold Company (The); Legrand.
 2. Hubbell
- B. All devices shall be furnished with protective blanking plate or concrete cover. Upon connection of conduit(s) and prior to concrete pour, covers shall be reinstalled to prevent infiltration of moisture and debris. Covers shall be removed only for cable pulling and wiring device installation, and remain in place until device and adjacent flooring are prepped for final cover.
1. Where indicated as flush, install device such that the cover is flush with finished grade. Where indicated as surface, install device such that there is no gap between the top of the floor and the bottom of the cover's flange. Prior to installation of concrete, coordinate with all other trades as necessary, consult manufacturer installation instructions, and utilize manufacturer tile shims/extension rings/accessories if needed to achieve required installation. Flooring around box shall not rise or depress to accommodate required installation.
 2. Provide complete with device mounting plates for duplex receptacles and the quantity of data/telephone outlets indicated on drawings. Coordinate type of data/telephone jacks with Owner and/or Division 27 specification sections. Provide blank service plates on all unused openings.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armorcast Products Company.
 2. Carson Industries LLC.
 3. CDR Systems Corporation.
 4. Highline
 5. NewBasis.
 6. Hubbell Quazite
- B. Description: Comply with SCTE 77.
1. Color of Frame and Cover: Standard color of manufacturer.
 2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, indicating service type contained within, i.e. "ELECTRIC" or "TELECOMMUNICATIONS".
 6. Length: Minimum (12) times the largest raceway diameter entering handhole.
 7. Width: As required by applicable trenching details and/or raceway separation requirements to accept number of incoming conduits.
 8. Depth: As required so that bottom is below frost line, minimum 24-inches.
 9. Tier Rating based on Part 3 Application of Handholes. Refer to Drawings.

- C. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two
- D. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
- E. Accessories: Provide listed voltage barrier in handholes to separate power from fiber and low voltage control cables where applicable.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
 - 1. Underground Conduit, Service Entrance and Feeders:
 - a. Straight runs:
 - 1) RNC, Type EPC-40-PVC, direct buried, or fiberglass, gray finish.
 - 2) Electrical-grade SDR13.5 black polyethylene with red stripe.
 - b. Underground longsweeps and concealed transitions to aboveground wall cavities or gear housings:
 - 1) Where required by Local Utility, GRC.
 - 2) RNC, Type EPC-40-PVC.
 - 3) Fiberglass.
 - 4) Gray finish.
 - 2. Underground and Under Slab Conduit, Telecommunications and Branch Circuits: RNC, Type EPC-40-PVC, or HDPE, Type EPEC-40 direct buried, or fiberglass.
 - 3. Under Concrete Building Slabs: RNC, Type EPC-40-PVC, or fiberglass. For raceways 1.5 inches in diameter and less, use PVC coated or corrosion-resistant tape-wrapped rigid steel elbows to transition from below slab, through slab to above slab, indoor raceway. For raceways 2-inches and larger, see feeder and communications conduit installation specified below.
 - 4. Exposed Exterior Transitions to Aboveground:
 - a. PVC-coated pre-fabricated elbows.
 - b. Wrapped GRC elbows.
 - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC
 - 6. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R or Type 4.
 - 7. Application of Handholes and Boxes for Underground Wiring:

- a. Handholes and Pull Boxes in Driveway and Parking Lot Locations, Subject to Occasional Loading by Heavy Vehicles: Polymer concrete SCTE 77, Tier 22 structural load rating.
- b. Handholes and Pull Boxes in Driveway and Parking Lot Locations, Subject to Occasional Nondeliberate Loading by Heavy Vehicles: Polymer concrete SCTE 77, Tier 15 structural load rating.
- c. Handholes and Pull Boxes in Sidewalks and Grassy Areas and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Heavy-duty fiberglass units with polymer-concrete frame and cover, SCTE 77, Tier 8 structural load rating.

B. Indoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT. Includes raceways in the following locations:
 - a. Unfinished, dry spaces.
 - b. Within joist space of finished spaces with exposed structure ceilings. Install raceway near top cord of joist where applicable. Maintain 1.5-inch clearance from roof deck. Avoid installing conduit along bottom cords of joist unless serving items mounted to the bottom cord of joists.
 - c. Finished areas with painted exposed structure: As required to house all types of low voltage cabling.
2. Exposed and Subject to Physical Damage: Rigid steel conduit. Includes raceways up to 8 feet above the finished floor in the following locations:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
3. Exposed Finished Space: Surface metal raceway. Limited to the following locations only:
 - a. Existing masonry walls.
 - b. Other areas as noted on drawings.
4. Concealed in Masonry Walls and Partitions: EMT. PVC shall be permitted where concealed in cells of masonry walls. Transition to EMT or IMC prior to either turning out into any exposed or plenum spaces, or protruding from top on masonry walls that do not go to deck.
5. Above-grade homeruns: EMT.
6. In finished areas with painted exposed structure, floating ACP or GWB clouds, baffle systems or other non-continuous concealed ceiling systems: EMT to all devices and fixture-to-fixture, with whips to each fixture.
7. Concealed in Ceilings and Interior Stud Walls and Partitions: EMT, except where Type MC cable is permitted.
 - a. Type MC cable shall be permitted as follows:
 - 1) Fixture Whip: Between a junction box and a light fixture or mechanical unit disconnect. Maximum length of fixture whip shall be 72-inches.

- 2) Connections between recessed light fixtures above accessible ceiling within a space. Provide Caddy clips at light fixture support wires where structure is not available. Fastening to ceiling support wires shall not be permitted.
 - 3) Branch conductors between device boxes in metal stud walls. Use of MC cable between devices in walls shall be limited to direct (through studs) routing only; routing from device up in the wall, over, and back down in the wall to the next device is not permitted.
 - 4) MC cable shall not be permitted room-to-room or room-to-corridor. Branch circuits in all spaces shall originate at a box fed via EMT.
 - 5) MC cable in corridors or hallways shall be limited to connections between recessed light fixtures in continuous concealed ceiling systems.
8. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 9. Damp or Wet Locations: Rigid steel conduit.
 10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size diameter for lighting and branch circuit homeruns. 1-inch (26-mm) for exterior work. 1/2-inch (16-mm) diameter for other interior work, unless shown or specified otherwise.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
 3. Plenum-rated Bushings: Apply to all thru-wall sleeves and low voltage device conduit stub-ups.

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. 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.
- C. Complete raceway installation before starting conductor installation.
- D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

- F. 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.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- H. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
- I. 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.
- J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- K. 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.
- L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, 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.
- M. 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.
- N. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
 - 1. Use LFMC in damp or wet locations
- O. 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.
- P. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. 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 PVC coated or corrosion-resistant tape-wrapped rigid steel elbows for stub-ups at poles and equipment, unless noted otherwise.
 - 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. Where feeder and communications conduits 2-inches in diameter and larger transition from below concrete floor slab to above slab, RNC may continue up to 36-inches maximum to destination (i.e. panelboard) without converting to the indoor raceway system specified above.

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes and boxes with bottom below the frost line.

3.5 DEVICE BOX INSTALLATION

- A. Install boxes for light switches and wall-box occupancy sensors shown on strike side of door within 12-inches of door/sidelight framing unless indicated otherwise.
- B. Install boxes for light switches and wall-box occupancy sensors shown on hinge side of door both clear of door swing and within 12-inches of door's open position.

- C. Boxes in casework, cabinets: Install face of box flush with casework surface. Provide box extenders as required for flush installation of box and devices.
- D. Provide a minimum of 24-inches of separation between boxes located back-to-back within a fire-rated wall, or provide fire-rated moldable putty pads at individual devices boxes where located within 24-inches of each other.

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 07 Section "Penetration Firestopping."

3.7 PAINT

- A. In finished areas with painted exposed structure, paint all exposed raceway, boxes, and j-box coverplates to match adjacent finishes. Finished areas include spaces with fully exposed structure, suspended baffle systems and floating architectural elements that do not extend to walls or are not continuous. Unfinished exposed raceway in finished spaces is not acceptable.

3.8 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260553 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for conductors and cable.
 - 2. Underground-line warning tape.
 - 3. Equipment identification labels.
- B. Related Requirements:
 - 1. Division 26 Section "Overcurrent Protective Device Study" for arc-flash warning labels.

1.3 SUBMITTALS

- A. Product Data: For warning tape.
- B. Custom Service Entrance Placard: Submit sample showing building footprint, transformer locations and main service disconnect locations.
- C. Sample: Submit sample for typical panelboard label.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CONDUCTOR AND -CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- C. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.2 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line. Red tape with 'ELECTRICAL' and orange tape with 'COMMUNICATIONS'.

2.3 EQUIPMENT IDENTIFICATION LABELS

- A. Electrical Distribution Equipment: Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).
- B. Wall Plates: Black letters on clear, self-adhesive backing. Minimum letter height shall be 1/4-inch (7mm).
- C. Refer to Drawings for information required to be displayed on labels.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Junction Boxes for Feeders and Branch Circuits: Provide label indicating panelboard and circuit number. Labels may be machine printed or handwritten with a permanent marker.
 - 1. Place label on outside of box cover in unfinished spaces and where concealed above finished ceilings, access panels, etc.
 - 2. Place label on inside of box cover where box is exposed in a finished space.
- B. Junction Boxes for Fire Alarm Systems: Provide red coverplates or paint coverplates red in the field.
- C. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list future load (if known), source and circuit number. Where located in an unfinished space or concealed in an accessible space above finished ceiling, label cover with permanent marker or adhesive label.
- D. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for direct-buried cables, cables in raceway, and empty raceway.
- E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Where required by NEC or local codes comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.
- F. Provide labels for the following equipment unless noted otherwise:
 - 1. Panelboards and Load Centers:
 - a. Provide label on exterior of panelboard above panelboard door.
 - b. Provide typed directory. The directory shall reflect final room numbers as assigned by the Owner, which may not match room numbers indicated on construction document drawings. Install directory in a metal frame or plastic pouch mounted on the inside cover of the panelboard.
 - 2. Switchboards:
 - a. Provide labels for switchboards.
 - b. Provide a label for each branch switch or breaker identifying the load served.
 - 3. Transformers.
 - 4. Disconnect switches, both interior and exterior:
 - a. Provide labels for heavy duty safety switches, combo disconnect starters and enclosed controllers.

- b. Labels are not required for motor rated toggle switches or switches with thermal overloads.
- 5. Motor starters:
 - a. Label shall identify the load served.
- G. Provide additional identification as required by NEC or local codes.

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. Color-Coding for Phase Identification, 600 V and Less: Use the colors listed below for service, feeder, and branch-circuit conductors.
 - 1. Color shall be factory applied or, for sizes larger than No. 10 AWG if authorities having jurisdiction permit, field applied.
 - 2. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 3. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Ground: Green.
 - 4. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

- F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 12 inches (300 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.

END OF SECTION 260553

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SECTION 260570 - OVERCURRENT PROTECTIVE DEVICE STUDY

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 a coordination and arc-flash study to determine the following:
 - 1. Recommended settings for adjustable overcurrent devices.
 - 2. Arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.3 DEFINITIONS

- A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.
- B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.
- C. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.4 SUBMITTALS

- A. Report Data: Submit output for the computer program used to perform the study. Result of study should include the following:
 - 1. Arc flash information for each piece of distribution equipment, i.e. switchboards, panelboards, and disconnect switches.
 - 2. Recommended setting for each overcurrent protection device with adjustable settings.
- B. Product Data: Arc Flash Warning Labels.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

- B. Operation and Maintenance Procedures: In addition to items specified in Section 017823 "Operation and Maintenance Data," provide the following:
 - 1. Maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.
 - 2. Recommended settings for overcurrent protection devices with adjustable settings.

1.6 QUALITY ASSURANCE

- A. Employ the manufacturer of the electrical distribution equipment, i.e. switchboards and panelboards, to perform the study specified herein.

PART 2 - PRODUCTS

2.1 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems." Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
 - 1. Location designation.
 - 2. Nominal voltage.
 - 3. Flash protection boundary.
 - 4. Hazard risk category.
 - 5. Incident energy.
 - 6. Working distance.
 - 7. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study.

3.2 LABELING

- A. Apply one arc-flash label for each 600-V ac, 480-V ac, and applicable 208-V ac panelboard and disconnect and for each of the following locations:
 - 1. Low-voltage switchboard.

3.3 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels.

END OF SECTION 260570

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SECTION 260923 - LIGHTING CONTROLS

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 the following digital lighting control devices:
 - 1. Network control devices for zone and/or room controllers.
 - 2. Room control devices.
 - 3. Ceiling/wall occupancy/vacancy sensors and low voltage switches.
 - 4. Wall box occupancy/vacancy sensors.
 - 5. Emergency lighting (UL 924) control devices.
- B. Related Sections include the following:
 - 1. Division 26 Section "Wiring Devices" for manual light switches.
 - 2. Division 26 Section "Lighting" for interior dimming light fixtures and exterior light fixtures requiring integral wireless control devices.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. IP: Internet protocol.
- C. LED: Light-emitting diode.
- D. PIR: Passive infrared.
- E. UL 924 control device: Emergency bypass devices for override of local dimmed or non-dimmed load control devices.

1.4 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each type of lighting control system and components.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 3. For each relay panel and related equipment, include:
 - a. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - b. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - c. Detail wiring partition configuration, current, and voltage ratings.
 - d. Short-circuit current rating of relays.
 - e. Include diagrams for power, signal, and control wiring.
 4. For all digital low voltage switches, submit labeling scheme for all devices. Prepare all manufacturer's custom labeling documentation and submit to manufacturer. Default engravings indicating ambiguous 'Zones' are unacceptable. Indicate terminology on labels as part of submittals.
- B. Drawings prepared by the manufacturer of the products proposed depicting quantity and location of network control devices, room control devices, ceiling occupancy/vacancy sensors and associated switches, wall box sensors, emergency lighting control devices, daylight harvesting photocells, and wireless exterior lighting control devices and associated transmitters or antennae.
1. Drawings shall be prepared at a scale of 1/8-inch equals one foot and include a symbol legend.
 2. Bid documents indicate the design intent as to the type of devices used to provide lighting control in each space. Obtain the manufacturer's guidance in determining the exact quantity, location, and type of detector and/or photocell to use in each space. Adjust (at no additional cost to the Owner) as recommended by the manufacturer to ensure coverage of each space based on the size and height of each space.
 3. For network and room control devices, provide project-specific wiring diagrams.
 4. For interior and exterior lighting control components, indicate system control devices, relays, UL 924 control devices and BAS interface devices and wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. Submit results of both interior and exterior networked, time-based control with BAS interface, occupancy sensor and photocell testing to both Owner and A/E within 90 days of Substantial Completion.
- C. Programming Report: Provide report summarizing control device settings and control function of all multi-button devices on a room-by-room basis. Multi-button devices shall include those controlling dimming and multiple scenes. Similar rooms can be grouped.

1.6 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. Regulatory Requirements: Comply with applicable city, county, and state codes and ordinances.
- C. Codes and Standards:
 - 1. NFPA 70, National Electrical Code (NEC).
 - 2. UL 508, Standard for Industrial Control Panels.
 - 3. UL 916, Standard for Energy Management Equipment.
 - 4. UL 917, Standard for Clock Operated Switches.
 - 5. UL 924, Standard for Emergency Lighting and Power Equipment.
 - 6. 47 CFR, Subparts A and B, for Class A digital devices.
- D. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than three years.
- E. Comply with NEC, NEMA, and FCC emission requirements for Class A applications.
- F. Source Limitations: Obtain lighting control components through one source from a single manufacturer's representative. System shall have an architecture that is based upon the following:
 - 1. Network lighting control devices and backbone infrastructure for remote or time-based control zone operations.
 - 2. Standalone sensor-based and/or manual lighting controls.

1.7 COORDINATION

- 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 system, and partition assemblies.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare relay panels for installation according to NECA 407.

1.9 WARRANTIES

- A. Lighting Control System Warranty:

1. Minimum of five years on all lighting control components including network devices, room controllers, power packs, relays, UL 924 devices, switches, sensors and photocells.

PART 2 - PRODUCTS

2.1 INTERIOR CONTROLS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Acuity Brands, Inc: nLight.
 2. Cooper Lighting Solutions: Greengate.
 3. Crestron Electronics, Inc.: GLS or Zum.
 4. Hubbell Control Solutions: NX.
 5. Legrand North America: Wattstopper DLM.
 6. Leviton Manufacturing Co.: GreenMAX.
 7. Sensorworx.
 8. Steinel.

2.2 NETWORK CONTROL SYSTEMS

- A. Control system shall provide time-based control and BAS interface for both interior and exterior lighting controls. Control types shall include, but not be limited to, the following:
 1. Interior daily on/off sweeps based on occupied/unoccupied BAS schedule.
 2. Exterior on/off control based on BAS astronomical dusk-to-dawn timeclock.
- B. System Topography: In addition to stand-alone controls, refer to Drawings for general intent of lighting controls.
 1. Control summary and switch detail indicates sensor technology, switch types and applicable control sequences.
 2. Details depict intent whereby pole-mounted area luminaires are controlled via relay panel (no programmed dimming), and all building mounted exterior luminaires and interior luminaires in time-based zones or spaces are controlled via wired control devices.
- C. BAS Interface:
 1. Devices controlling both interior and exterior time-based lighting loads shall serve as input points to the BAS system. Provide all necessary input points to BAS system provider as required in the control summary.
 - a. The communications protocol shall be compatible with the BAS system: BAC Net or LonWorks. Coordinate with Division 23.
 2. Owner interface with lighting control system shall be limited to system access and adjustment via BAS system interface. Cloud-based system access shall be via LAN.

System software shall reside on Owner's LAN only if required to provide updates to network control components. Owner shall not be required to access control platform to make control adjustments.

2.3 NETWORK CONTROL DEVICES

- A. Description: All control devices shall be interconnected with plenum-rated UTP cabling to appear to the operator as a single lighting control system. System programming shall be done in the following fashion:
 - 1. For completely networked systems, system programming and control adjustments can be done via software from a single point in the network.
 - 2. For stand-alone systems, programming shall be done by handheld remote control or by software app via standard wireless protocol such as wi-fi or Bluetooth.
- B. Power Supply: NFPA 70, Class 2, sized for connected equipment. Powered from a line-voltage branch circuit, sized to provide control power for connected devices.
- C. Operator Interface: Programming components, including handheld IR devices, mobile software applications, dongles, and all other accessories required for complete system programming and operational adjustments.
- D. Device Enclosures: Enclosures shall be hinge locking in lieu of screw cover type.
- E. Lighting Control Zones:
 - 1. Zones shall consist of one or more lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher-level network backbone.
 - 2. Devices within a lighting control zone shall be connected with low voltage cabling, in a daisy-chain fashion, and in any order.
 - 3. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.
 - 4. Power for control devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, or from the network backbone.
- F. System shall have a primary network control "gateway" device that is capable of accessing and controlling connected system devices and linking into an Ethernet LAN.
- G. System shall use "bridge" devices that route communications for up to 8 lighting zones together for purposes of decreasing system wiring requirements.
- H. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.
- I. Lighting Control Relay Panels: Provide where required for multi-level zone control and/or non-dimming exterior lighting control.

1. Panels shall be configured with the quantity of relays and 0 - 10 volt dimming interior channels as indicated.
2. Provide capacity for 8, 16, 24, 32, or 48 relays in each panel as indicated.
3. Panel shall incorporate normally closed latching relays capable of switching 120/277 VAC loads.
4. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
5. Relays shall have a minimum Short Circuit Current Rating (SCCR) of 14,000A.
6. Internal barriers shall be provided where UL 924 emergency loads are present.
7. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connections.
8. Dimming channels shall be assignable to control zones as required via the control software.
9. Dimming channels shall be configurable to respond to manual raise/lower wall switch control stations, preset scenes, or daylight harvesting photocells.

2.4 ROOM CONTROL DEVICES

- A. Devices shall include, but not be limited to, the following:
1. Room controllers.
 2. Power packs.
 3. Relays.
 4. Emergency lighting (UL 924) control devices for local manual control of fixtures with integral or remote emergency power source.
 5. Programming components, including handheld IR devices, mobile software applications, dongles, and all other accessories required for complete system programming and operational adjustments.
- B. Devices used for localized control of lighting loads shall perform one or more of the following functions, refer to Drawing Details:
1. ON/OFF control.
 2. Dimming Control (Where Designated on Drawings): On/off/dimming switches shall be connected to localized room controllers. Continuous dimming to 10% for general lighting and emergency lighting via UL 924 control device.
 - a. Continuous Dimming to 10%: Duration of dimming (ramp up and fade down time) from 100% to 10% and vice-versa shall be five seconds.
 3. Networked time-based or occupancy-based programmable ON/OFF control (Where Designated on Drawings). Multiple room controllers in spaces designated as time-based or occupancy based shall be networked together via UTP plenum cable to provide simultaneous control.
- C. Manual Switches and Plates: Connect directly to room controller or daisy-chain switchers via 4-pair UTP plenum-rated cable.
1. Low Voltage ON/OFF Control Switches: Heavy duty manual (SL) or key operated switches (\$L).

- a. Manual Switches: Provide one of the following:
 - 1) Single-pole, double-throw, center position rest Decora-style rocker
 - 2) Two-button push-button type switch with ON/OFF designations.
 - 3) Momentary contact pushbutton switch.
 - b. Provide one of the following products, or approved equal:
 - 1) Wattstopper LMSW-101
 - 2) Leviton DRKDN-C Series
 - 3) Sensorworx SWX Series.
 - 4) Steinel DCS Wall Switch Series
 - c. Key Operated Switches: Single-pole, double-throw, center position rest key switch with illuminated 'ON' and 'OFF' indicator lights (if offered), or approved equal:
 - 1) Acuity Brands nPOD KEY.
 - 2) Leviton 1221-2KL.
 - 2. Multi-Button Low Voltage Control Switches (SA/AD/LD/LP/M/OD/PD/TD/VD): Multi-button digital low voltage programmable control switches with labels. Refer to Drawings for the following:
 - a. Quantity of switches and number of buttons per switch.
 - b. Labeling: Provide custom factory labeling to reflect individual button functions.
 - c. Functionality: ON/OFF, dimming with continuous up/down or preset controls.
 - D. Color: Gray. Color shall match wiring devices as specified in Division 26 Section "Wiring Devices". If color is not available, submit color options with shop drawings for A/E to select from manufacturer's standard color offering.
 - E. Wall Plates: Discard vinyl plate provided with device and provide Decora style stainless steel plate suitable for use with device. Confirm devices will operate within dimensions of opening in steel plate.
- 2.5 INDOOR CEILING/WALL MOUNT OCCUPANCY AND VACANCY SENSORS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acuity Brands, Inc.: SensorSwitch
 - 2. Cooper Lighting Solutions.
 - 3. Crestron Electronics, Inc.
 - 4. Hubbell Control Solutions.
 - 5. Legrand North America: Wattstopper.
 - 6. Leviton Manufacturing Co.
 - 7. Sensorworx.
 - 8. Steinel.

B. General Description: Solid-state units with a separate power pack or relay unit.

1. Occupancy Sensor (Auto-On) Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time-delay for turning lights off, adjustable over a minimum range of 1 to 20 minutes.
2. Vacancy Sensor (Manual-On) Operation: Unless otherwise indicated, manual activation of low voltage switch(es) shall activate lights within a space and activate operation of sensor such that lights remain on when area is occupied. Sensor shall turn lights off when space is unoccupied and reset to manual on status. Time delay shall be adjustable over a minimum range of 1 to 20 minutes.
3. Low-voltage switches shall provide manual off operation. Sensors shall reset to auto or manual-on operation after short preset time-delay.
4. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
5. Relay Unit: Dry contacts rated for 20-amp LED driver load at 120- and 277-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 15-24 VDC, up to 150-mA, Class 2 power source as defined by NFPA 70.
6. Mounting:
 - a. Ceiling Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Wall Mount Sensor: Suitable for mounting in an adjustable position on a single-gang box via included swivel mounting bracket.
 - c. Power pack or Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
7. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door or unit base.
8. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
9. Bypass Switch: Override the on function in case of sensor failure.
10. Automatic Light-Level Sensor (where required): Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
11. Finish: White.
12. Recommended Settings: Provide the following factory-programmable or dipswitch settings:
 - a. Occupancy Sensors: Auto-On enabled.
 - b. Vacancy Sensors: Manual-On enabled.
 - c. Self-adjusting delayed-OFF feature enabled.
 - d. Ambient light override disabled.
 - e. Audible alert disabled.
 - f. Visible alert (LED indicator) enabled.
 - g. Sensitivity: High.
 - h. Time Delay: 20 minutes, unless directed otherwise by Owner.
 - i. Dual-Technology Mode Settings: Detection by either technology (not both) will turn lights on and keep them on.

C. Ceiling Dual-Technology Type: Detect occupancy by using a combination of PIR and microphonic or ultrasonic detection methods in area of coverage. 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- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - a. Provide one of the following:
 - 1) Crestron Quattro Series
 - 2) Cooper Lighting Occupancy: OAC-DT-2000-R
 - 3) Cooper Lighting Vacancy: VAC-DT-2000-R
 - 4) Hubbell OMNI-DT2000 (no relay or integral photocell)
 - 5) Leviton OSCxx-M Series
 - 6) Sensor Switch CM PDT 10 (no relay or integral photocell)
 - 7) Sensorworx SWX-22x Series
 - 8) Steinel DT Quattro Series
 - 9) Wattstopper DT-300

D. Ceiling PIR Type: Detect occupants in coverage area by their heat and movement.

1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 - a. Provide one of the following products, or approved equal:
 - 1) Cooper Lighting OAC-DT-1000-R
 - 2) Leviton OSCxx-I Series
 - 3) Sensorworx SWX-21x
 - 4) Steinel IR Quattro HD Series

E. High Mount Applications:

1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 240-inch- (6100-mm-) high ceiling.
 - a. Provide one of the following products, or approved equal:
 - 1) Sensor Switch CM 6 Series

F. Wet and/or High-Humidity Applications:

1. Detector Environmental Rating: Provide detector suitable for wet/humid environments.
- G. Wall or Corner PIR Type: Detect occupants in coverage area by their heat and movement.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room): Detect occupancy anywhere in a minimum 90-degree area of 1000 sq. ft. (93 sq. m) when wall mounted 94-inches (2380-mm) aff.
 - a. Provide one of the following products, or approved equal:
 - 1) Leviton OSWWV Series
 - 2) Steinel IR CM Series
 - 3) Sensorworx SWX-401 Series
 - 4) Wattstopper LPMX-100 high-density (minor motion)

2.6 WALL BOX OCCUPANCY AND VACANCY SENSORS

A. General Description:

1. Occupancy Sensor (Auto-On) Operation: Turn lights on when covered area is occupied and off when unoccupied; with an adjustable time-delay for turning lights off.
2. Vacancy Sensor (Manual-On) Operation: Manual activation of switch shall activate lights within a space and activate operation of sensor such that lights remain on when covered area is occupied. Sensor shall turn lights off when space is unoccupied and reset to manual on status. Time delay shall be adjustable.
3. On/off switch shall provide manual off operation. Sensors shall reset to auto or manual-on operation at conclusion of time-delay setting.
4. Sensor Output: Contacts rated to operate the connected load, complying with UL 773A.
5. Description: 120/277 V, adjustable time delay range from 1-20 minutes, 180-degree field of view, with a minimum coverage area of 300 sq. ft. (28 sq. m.) for minor motion. Load rating of 800 W at 120 V, 1200 W at 277 V.
6. Mounting:
 - a. Suitable for mounting in any position on a standard outlet box.
 - b. Time-Delay and Sensitivity Adjustments: Recessed and concealed.
7. Bypass Switch: Override the on function in case of sensor failure.
8. Automatic Light-Level Sensor (where required): Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
9. Recommended Settings: Provide the following dipswitch settings:
 - a. Auto-On enabled: Single-person restrooms only unless noted otherwise.
 - b. Manual-On enabled: All non-restroom spaces.
 - c. Self-adjusting delayed-OFF feature enabled.
 - d. Ambient light override disabled.
 - e. Audible alert disabled.
 - f. Visible alert (LED indicator) enabled.
 - g. Sensitivity: High.

- h. Time Delay: 10 minutes, unless directed otherwise by Owner.
- B. Single-Relay PIR Wall Box Sensors (O = Occupancy, Auto-On, V = Vacancy, Manual On):
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; ONW-P-1001-MV
 - b. Hubbell; LHIRS1G
 - c. Leviton ODS10-ID
 - d. Sensor Switch; WSX
 - e. Sensorworx SWX-10x
 - f. Steinel; IR WLS 1
 - g. Watt Stopper (The); PW-100
- C. Single-Relay Dual-Technology Wall Box Sensors (O = Occupancy, Auto-On, V = Vacancy, Manual On):
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; ONW-D-1001-MV
 - b. Hubbell; LHMTS1G
 - c. Leviton OSSMT-GD
 - d. Sensor Switch; WSX-PDT
 - e. Sensorworx SWX-12x
 - f. Steinel; DT WLS 1
 - g. Watt Stopper (The); DW-100
- D. Single-Relay Dual-Technology Wall Box Sensors with Dimming (VD = Vacancy, Manual On, Dimming):
 - 1. Continuous Dimming to 10%: Duration of dimming (ramp up and fade down time) from 100% to 10% and vice-versa shall be a maximum of five seconds.
 - 2. Products: Subject to compliance with requirements, provide one of the following, or approved equal:
 - a. Hubbell; LHDMMTS
 - b. Sensor Switch; WSX-D
 - c. Sensorworx SWX-12x-D
 - d. Steinel; DT WLS DIM
 - e. Watt Stopper (The); DW-311
- E. Color: Gray. Color shall match wiring devices as specified in Division 26 Section "Wiring Devices". If color is not available, submit color options with shop drawings for A/E to select from manufacturer's standard color offering.
- F. Wall Plates: Discard vinyl plate provided with device and provide Decora style stainless steel plate suitable for use with device. Confirm devices will operate within dimensions of opening in steel plate.

2.7 EMERGENCY LIGHTING (UL 924) CONTROL DEVICES

- A. Emergency bypass devices rated for load being served. Device shall override local dimming or non-dimming load controls by sensing normal power failure in space. Manufacturer shall match non-emergency room controller.

2.8 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. All control cabling shall be plenum rated.
- D. Per NEMA standards, 0-10VDC control cabling insulation shall be pink and/or purple; gray is unacceptable.

PART 3 - EXECUTION

3.1 FACTORY COMMISSIONING

- A. Factory authorized representative will be available for a pre-wiring meeting to review submittal drawings, recommended wiring practices and programming requirements.
- B. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system. Provide no-less than three weeks' notice to schedule a start-up visit. Several business days may be required to confirm dates and times.
- C. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.
- D. Upon completion of the system commissioning the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

3.2 NETWORK CONTROL DEVICES AND ROOM CONTROL DEVICES

- A. Examination:
 - 1. Examine elements and surfaces to receive devices for compliance with installation tolerances and other conditions affecting performance of the Work.
 - 2. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Installation:

1. Comply with NECA 1.
2. Mount devices plumb and rigid, within 24-inches of accessible ceiling below.
3. In areas with accessible ceilings, locate plenum-rated devices just above ceilings, adjacent to corridors, preferably near entryways, where power supplies enter the space.
 - a. Where accessible ceilings extend to above door openings, mount controllers just above door.
 - b. Where GWB soffits run along walls or above doors, locate controllers on vertical face at accessible ceiling edge.
4. In finished areas with painted exposed structure, locate controls in a white, wall-mounted NEMA 1 enclosure above corridor entry door in joist space.
5. In high ceiling spaces, it is permissible to locate control devices in adjacent unfinished spaces, provided devices are labeled according to room served.
6. In areas with GWB ceilings, locate devices adjacent to access panel within space or in adjacent accessible space. Label according to room served.
7. Locate all calibration devices such that they are readily accessible.

C. Identification:

1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - a. Circuit Identification: At device housing, provide machine-printed label indicating line voltage circuit(s) associated with device.

D. Verification:

1. Prior to completion, controllers shall be adjusted for proper operation. Proper operation includes:
 - a. Input devices provide proper on/off/dimming control of localized loads, including UL 924 control devices.
 - b. Lights stay 'on' while the space is in occupied mode. Lights turn 'off' when the space is unoccupied after a preset time delay.
 - c. Emergency loads are controlled with adjacent non-emergency loads. In the event of normal power failure, emergency loads default to full brightness.
 - d. Provide final walk-thru with Owner to verify accuracy of settings, including proper operation of emergency fixtures. Document results of testing via results of Owner walk-thru (pass/fail format).

E. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
 - a. Complete installation and startup checklists per manufacturer's written instructions.
 - b. Confirm correct communications wiring, initiate communications between control devices, between control devices and loads, and program the lighting control system per approved configuration schedules.

- c. Provide a minimum of four hours training for Owner's maintenance personnel on adjusting controller settings as well as local switch ON/OFF and raise and lower controls.
 - 1) Notify Owner in advance of scheduled training to bring all necessary mobile devices for download of mobile software applications.

3.3 SENSORS

A. Installation:

- 1. Install and aim sensors in locations to achieve 100 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. Verification:

- 1. Prior to completion, sensors shall be adjusted for proper operation. Proper operation includes:
 - a. Occupancy Sensing: Lights are turned 'on', immediately upon entering the space.
 - b. Vacancy Sensing: Lights turn 'on' via manual switch activation.
 - c. Lights stay 'on' while the space is occupied.
 - d. Lights turn 'off' when the space is unoccupied after a preset time delay since last detecting occupancy.
 - e. Recommended settings are incorporated via dipswitch settings for all non-adaptive technology devices.
 - f. Provide final walk-thru with Owner to verify accuracy of settings. Document results of testing via results of Owner walk-thru (pass/fail format).

C. Startup Service:

- 1. Provide a minimum of one-hour training for Owner's maintenance personnel on adjusting all dipswitch settings.

3.4 DIMMING CONTROLS

A. Occupancy/Vacancy Sensor Manual ON/OFF/DIMMING Control Switches:

- 1. Provide a minimum of one-hour training for Owner's maintenance personnel on adjusting controller settings, including tap on/off control, press and hold raise and lower control, Auto-On light level presets (or default to last level) and ramp up and fade down times.

B. Wall Box Sensors with Dimming (VD = Vacancy, Manual On, Dimming):

- 1. Provide a minimum of one-hour training for Owner's maintenance personnel on adjusting controller settings, including Auto-On/Manual-On, Auto-On light level presets (or default to last level), time delay, ramp up and fade down times, smart light level, walk-thru and test modes.

3.5 PROGRAMMING REPORT

- A. Provide report summarizing control strategy for all spaces. Include scheduled on/off programming, manual or auto on/off function, dimming function, 'blink-warning' functions and individual button performance on multi-button switches.

3.6 WIRING INSTALLATION

- A. Obtain control device manufacturer's wiring diagrams to determine all devices, components, line and low voltage connections.
- B. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm). Install cables in raceways meeting the requirements for branch circuit wiring as specified in Division 26 Section "Raceways and Boxes for Electrical Systems:" in all locations except as follows:
 - 1. Cable is not required to be installed in raceway where concealed in an accessible space above finished ceilings. Install plenum cable in environmental air spaces, including plenum ceilings. Provide sleeves as specified in Division 26 Section "Common Work Results for Electrical Systems" where cable passes through walls. See Open-Cable Installation below.
- C. Open-Cable Installation.
 - 1. Utilize cable tray where available.
 - 2. Suspend cable not in a cable tray or pathway a minimum of 6 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
 - 3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
 - 4. Route cable parallel or perpendicular to building structure.
 - 5. In finished areas of painted exposed structure, conceal all control cabling in raceway.
 - 6. Where concealed above continuous ceilings, utilize D-rings or J-hooks along walls where tray is not available. Rigidly support J-hooks from wall, from structural members whose bottom cord is within 48-inches of suspended ceiling below, or from thread rod in areas with high structure above suspended ceilings. Bridle rings may be used at bottom of structure to support cable serving devices centered in spaces away from walls. Use of cable ties shall not be permitted.
 - 7. Do not support cables by Caddy clips and ceiling support wires.
 - 8. Provide 6-foot service loop above all devices mounted in accessible ceiling to allow for device location flexibility. Support service loop with j-hook or bridle ring.
- D. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- E. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.7 DEVICE INSTALLATION

- A. In finished areas of painted, exposed structure, conceal all control components in a NEMA enclosure.

3.8 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 and prepare test reports:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 3. Operational Test: Verify operation of each lighting control device, and adjust time delays.
 - 4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Lighting control devices that fail tests and inspections are defective work.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain network control devices and room controllers, operator interface software, calibration equipment, sensors and switches.

3.10 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting control panel, device or gateway settings, room controller settings, sensor settings and photocell sensor adjustment and relocation to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

END OF SECTION 260923

SECTION 262200 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
 - 1. Distribution transformers.

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. Field quality-control test reports.
- D. 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."

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 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 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.
- 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 or Copper.

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 unless noted otherwise.
 - 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: Gray
- E. Taps for Transformers Smaller Than 3 kVA: None.
- F. Taps for Transformers 7.5 to 24 kVA: Two 5 percent taps below rated voltage.
- G. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- H. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.
- I. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - 1. Complying with the 2016 Department of Energy 10CFR 431 standard.
- J. Low-Sound-Level Requirements: Maximum sound levels when factory tested according to IEEE C57.12.91, as follows:
 - 1. 9.00 kVA and Less: 40 dBA.
 - 2. 9.01 to 30.00 kVA: 45 dBA.
 - 3. 30.01 to 50.00 kVA: 45 dBA for K-factors of 1, 4, and 9.
 - 4. 50.01 to 150.00 kVA: 50 dBA for K-factors of 1, 4, and 9.

2.4 ACCESSORIES

- A. Wall-Mounting Brackets: Provide factory-supplied mounting bracket accessory where indicated on plans.

2.5 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.6 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. Maximum ground resistance shall be 5 ohms at location of transformer.
- 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.

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- B. Remove and replace units that do not pass tests or inspections and retest as specified above.

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 262200

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SECTION 262413 - SWITCHBOARDS

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 service and distribution switchboards rated 600 V and less.
- B. Related Sections include the following:
 - 1. Section 033000 "Cast-in-Place Concrete" for housekeeping pads.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. ERMS: Energy reduction maintenance switch.
- C. GFCI: Ground-fault circuit interrupter.
- D. GFPE: Ground fault protection of equipment.
- E. RFI: Radio-frequency interference.
- F. RMS: Root mean square.
- G. SPD: Surge protection device.
- H. SPDT: Single pole, double throw.

1.4 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of switchboards and overcurrent protective devices.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 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 curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain switchboards through one source from a single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NEMA PB 2, "Deadfront Distribution Switchboards."
- E. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in sections or lengths that can be moved past obstructions in delivery path.
- B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. Handle switchboards according to NEMA PB 2.1 and NECA 400.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2000 m).

1.8 COORDINATION

- A. Coordinate layout and installation of switchboards 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.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:
 - 1. ABB.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS

- A. Front-Connected, Front-Accessible Switchboard: Fixed, individually mounted main device(s), panel-mounted branches, and sections rear aligned.
- B. Nominal System Voltage: As indicated on Drawings.
- C. Main-Bus Continuous: As indicated on Drawings.
- D. Indoor Enclosures: Steel, NEMA 250, Type 1 unless noted otherwise.
- E. Outdoor Enclosures: Steel, NEMA 250, Type 3R unless noted otherwise.
- F. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

- G. Utility Metering Compartment: Fabricated compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
- H. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- I. Buses and Connections: Three phase, four wire, unless otherwise indicated.
 - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - a. If bus is aluminum, use copper- or tin-plated aluminum for circuit-breaker line connections.
 - b. If bus is copper, use copper for feeder circuit-breaker line connections.
 - 2. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) minimum-size, hard-drawn copper of 98 percent conductivity, equipped with pressure 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. Contact Surfaces of Buses: Silver plated.
 - 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections, unless noted otherwise. Provide for future extensions from ends where indicated.
 - 5. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus are braced.
- J. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of compartment.

2.3 SURGE PROTECTIVE DEVICES (SPD)

- A. Factory installed, integrally mounted, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
- B. UL 1449 3rd Edition Type 1 Device, 20kA nominal (L-N) rating.
- C. Minimum single-impulse current rating per phase shall be as follows:
 - 1. Line to Neutral: 200,000A.
 - 2. Line to Ground: 200,000A.
- D. Protection modes shall be as follows:
 - 1. Line to neutral.
 - 2. Line to ground.
- E. EMI/RFI Noise Attenuation per UL 1283: -50 dB at 100 kHz.

- F. Maximum UL 1449 Listed Voltage Protection Ratings (VPR's) shall not exceed the following:
 - 1. 1200 V, line to neutral and line to ground on 277/480 V systems.
 - 2. 1800 V, line to line on 277/480 V systems.
- G. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) shall not exceed the following:
 - 1. 15%, allowable system voltage fluctuation on 277/480 V systems.
 - 2. 320 V, MCOV on 277/480 V systems.
- H. Accessories:
 - 1. Audible alarm activated on failure of any surge diversion module.
 - 2. Six-digit transient-counter set to total transient surges that deviate from the sine-wave envelope by more than 125 V.

2.4 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 3, 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 magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. GFCI Circuit Breakers: Single- and two-pole configurations with 30-mA trip sensitivity.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
 - 1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
 - 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 - 3. Ground-Fault Protection (Where Indicated): Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - 4. Shunt Trip (Where Indicated): 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

2.5 ENERGY REDUCING MAINTENANCE SWITCH

- A. Maintenance Switch shall be a two-position switch marked "Normal Mode" and "Maintenance Mode" or similar language for the purpose of temporarily reducing the arc-flash potential while inspecting or performing work on equipment.
- B. Maintenance Mode: When the switch is set to Maintenance Mode, the associated circuit breaker trip unit delay setting is set to zero or "no intentional delay" to reduce the clearing time while a worker is working with the arc-flash boundary.

- C. Normal Mode: When the switch is set to Normal Mode, the associated circuit breaker trip unit delay setting is returned to the setting on the breaker trip unit.
- D. Local Status Indicator: Switch shall be furnished with a warning light that illuminates when the switch is set in Maintenance Mode.
- E. Instructions: Provide a laminated 8.5-inch x 11-inch instruction sheet with the manufacturer's recommended practice for use of the maintenance switch. Post instructions near the switchboard.
- F. Square D Alternate Maintenance Setting Switch (AMS) or equal by one of the approved switchboard manufacturers.

2.6 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
 - 1. Integrally mounted and factory installed.
 - 2. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - 3. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
 - 4. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 - 5. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondaries to ground overcurrent relays to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker ground-fault protection.
- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
 - 1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Megawatts: Plus or minus 2 percent.
 - e. Power Factor: Plus or minus 2 percent.
 - f. Frequency: Plus or minus 0.5 percent.
 - g. Megawatt Demand: Plus or minus 2 percent; demand interval programmable from 5 to 60 minutes.
 - h. Accumulated Energy, Megawatt Hours: Plus or minus 2 percent. Accumulated values unaffected by power outages up to 72 hours.
 - 2. Meter shall be compatible with and monitored by the Building Management System, BMS. Coordinate requirements with Division 23, provide pulse (KYZ) connection capability.
 - 3. Mounting: Display and control unit flush or semi-flush mounted in switchboard.

2.7 CONTROL POWER

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

PART 3 - EXECUTION

3.1 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.2 EXAMINATION

- A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1 and NECA 400.
- B. Install and anchor switchboards level on concrete bases, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete".
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Install overcurrent protective devices.

3.4 IDENTIFICATION

- A. Switchboard Nameplates: Label switchboard and each branch breaker or switch per Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.
 - 3. Surge protective device (SPD) panelboards.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. MCCB: Molded-case circuit breaker.
- E. RFI: Radio-frequency interference.
- F. RMS: Root mean square.
- G. SPD: Surge protective device.
- H. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Submit written Short Circuit and Coordination Studies, Arc-Flash Hazard Analysis and reports, as required by Section 260570 concurrently or prior to submittals required by this section.
- B. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, SPDs, accessories, and components indicated.

2. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- C. Shop Drawings: For each panelboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details.
 2. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Enclosure types and details for types other than NEMA 250, Type 1.
 - b. Bus configuration, current, and voltage ratings.
 - c. Short-circuit current rating of panelboards and overcurrent protective devices.
 - d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.
 - e. Breaker configuration: Where indicated on Drawings, individual breaker order and locations shall match panelboard schedules.
 - f. Fire alarm lockout device and label.

1.5 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through one source from a single manufacturer.
- B. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.
- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of panelboards and are based on the specific system indicated.

- 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 NEMA PB 1.
- F. Comply with NFPA 70.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2000 m).

1.9 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, and encumbrances to workspace clearance requirements.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.
 - 1. Panelboard Warranty Period: 18 months from date of Substantial Completion.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace SPD that fails in materials or workmanship within specified warranty period.
 - 1. SPD Warranty Period: Five years from date of Substantial Completion.

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. Keys: Four spares for each type of panelboard cabinet lock.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB.
 2. Eaton Electrical Inc.; Cutler-Hammer Products.
 3. Siemens Energy & Automation, Inc.
 4. Square D; Schneider Electric.

2.2 MANUFACTURED UNITS

- A. Enclosures: Flush or surface-mounted cabinets as indicated. NEMA PB 1 unless noted otherwise.
1. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
 2. Indoor Dry and Clean Locations: Steel, NEMA 250, Type 1 unless noted otherwise.
 3. Kitchen and Wash-down Areas: NEMA 250, Type 4X.
 4. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 5. Outdoor Locations: Steel, NEMA 250, Type 3R unless noted otherwise.
 6. Enclosure Finish: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
 7. Directory Card: With transparent protective cover, mounted in metal frame or plastic pouch, inside panelboard door.
- B. Phase and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- C. Conductor Connectors: Suitable for use with conductor material.
1. Main and Neutral Lugs: Mechanical type.
 2. Ground Lugs and Bus Configured Terminators: Compression 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.
- D. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

2.3 PANELBOARD SHORT-CIRCUIT RATING

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity. Series rated devices are not acceptable.
 - 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 - 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.4 DISTRIBUTION PANELBOARDS

- A. Main Overcurrent Protective Devices: Breakers or fused switches as indicated on Drawings.
- B. Branch Overcurrent Protective Devices:
 - 1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
 - 2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
 - 3. Fused switches.
- C. Fusible Distribution Panelboard: Square D QMB Series, or approved equal.
- D. Circuit Breaker Distribution Panelboard: Square D I-Line Series, or approved equal.

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- B. Mains: As indicated on plans.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike
- E. The number of poles of branch breaker space in a typical cabinet shall not exceed 42 unless noted otherwise. Where panelboards require more than 42-poles of space but less than 84-poles of space, provide a single cabinet with increased height. Where panelboards require 84-poles of space, provide two cabinets each with an equal amount of branch breaker space, unless noted otherwise.

2.6 SURGE PROTECTIVE DEVICE (SPD) PANELBOARDS

- A. Comply with the requirements for Lighting and Appliance Branch Circuit Panelboards above.

- B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 - C. Main Overcurrent Devices: Thermal-magnetic circuit breaker.
 - D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers.
 - E. Bus: Copper phase and neutral buses.
 - F. Surge Protective Device: Factory installed, integrally mounted, plug-in-style, solid-state, parallel-connected, sine-wave tracking suppression and filtering modules.
 - 1. UL 1449 3rd Edition Type 2, 5kA nominal (L-N) rating.
 - 2. Minimum Single-Impulse Current Ratings per Phase:
 - a. Line to Neutral: 80,000 A.
 - b. Line to Ground: 80,000 A.
 - c. Neutral to Ground: 40,000 A.
 - 3. Protection modes shall be as follows:
 - a. Line to neutral.
 - b. Line to ground.
 - c. Neutral to ground.
 - 4. EMI/RFI Noise Attenuation per UL 1283: -50 dB at 100 kHz.
 - 5. Maximum UL 1449 Listed Voltage Protection Ratings (VPR's) shall not exceed the following:
 - a. 1200 V, line to neutral and line to ground on 277/480 V systems.
 - b. 700 V, line to neutral and line to ground on 120/208 V systems
 - c. 1800 V, line to line on 277/480 V systems.
 - d. 1200 V, line to line on 120/208 V systems.
 - G. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) shall not exceed the following:
 - 1. 15%, allowable system voltage fluctuation on 277/480 V systems.
 - 2. 25%, allowable system voltage fluctuation on 120/208 V systems.
 - 3. 320 V, MCOV on 277/480 V systems.
 - 4. 150 V, MCOV on 120/208 V systems.
 - H. Accessories:
 - 1. Audible alarm activated on failure of any surge diversion module.
- 2.7 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES
- A. Molded-Case Circuit Breaker (MCCB): 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 magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. GFCI Circuit Breakers: Single- and two-pole configurations with 5 or 30-mA trip sensitivity as indicated on Drawings.
 3. Subfeed Circuit Breakers: Vertically mounted.
 4. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
 3. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 4. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 5. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- D. Fuses are specified in Section 262813 "Fuses."

2.8 ACCESSORIES

- A. Lock-out Devices: Provide lock-out devices on breakers serving appliances, including warm-air hand dryers, as required by Code and the local authority having jurisdiction, and as indicated in Panel Schedules.
- B. Fire Lockout Kit: Provide lockout kit with red identification labeling the branch circuit serving the fire alarm system.
1. Comply with NEC Article 760.
 2. Subject to compliance, provide one of the following, or approved equal:
 - a. TC Life Safety Elock-FA E-Series Circuit Lockout Kit with labeled circuit breaker lock and label for breaker exterior adjacent to panel door, visible without opening door, or approved equal red lockout device and red label with white lettering.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install panelboards and accessories according to NEMA PB 1.1.
- B. Mount top of trim 74 inches (1880 mm) above finished floor, unless otherwise indicated.
- C. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- D. Install overcurrent protective devices and controllers.
- E. Install filler plates in unused spaces.
- F. For panelboards mounted flush in walls, stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

- A. Identify field-installed conductors and panelboards as specified in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable. Directories shall reflect room numbers as assigned by the Owner, which may not match room numbers indicated on contract document drawings.
- C. Panelboard Nameplates: Label each panelboard as specified in Section 260553 "Identification for Electrical Systems."

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 2. Test continuity of each circuit.
- B. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. 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.

3.5 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 262416

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SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

1. Straight blade receptacles.
2. GFCI straight blade receptacles.
3. Receptacles with USB ports.
4. Twist-locking receptacles.
5. Snap switches.
6. Wall plates.
7. Pendant cord-connector devices.
8. Cord and plug sets.
9. Industrial cord reels.
10. Push-button stations and buzzers.
11. Rotary timer switches.
12. Pilot lights.
13. Clear protective device covers.

- B. Related Sections include the following:

1. Section 033000 "Cast-in-Place Concrete" for pole bases.
2. Section 271000 "Telecommunications Cabling" for workstation outlets.

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. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

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

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

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. Arrow-Hart Devices; Eaton (Eaton), formerly Cooper Wiring Devices.
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 GENERAL

- A. Contractor has the option to provide wiring devices with built-in factory assembled connectors and plugs with pre-terminated pigtails of the same series as the devices below. Such devices shall be Pass & Seymour PlugTail series or equal by one of the manufacturers listed above.
- B. Weather Resistant: Provide weather resistant version of the same series as devices specified below for all receptacles installed in wet and damp locations.

2.3 STRAIGHT BLADE RECEPTACLES

- A. General Description: 125 V, 20 A. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Eaton; 5361 (single), 5352 (duplex).
 - b. Hubbell; HBL5361 (single), 5362 (duplex).
 - c. Leviton; 5361 (single), 5362 (duplex).
 - d. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI STRAIGHT BLADE RECEPTACLES

- A. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Eaton; GF20.
 - b. Hubbell; GF5362.
 - c. Leviton; G5362.
 - d. Pass & Seymour; 2097.

2.5 RECEPTACLE WITH USB PORTS

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498. Tamper-resistant duplex receptacle with two USB charging ports in center of device. USB ports shall be rated for minimum of 5.1amps at 5vDC combined, One (1) 2.0 Type-A and one (1) Type-C.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Pass & Seymour; TR20USBACGRY or equal product by one of the following:
 - a. Cooper.
 - b. Hubbell.
 - c. Leviton.

2.6 TWIST-LOCKING RECEPTACLES

- A. Description: Single locking-type convenience receptacles: Comply with NEMA WD 1, NEMA WD 6 and UL 498.
1. Products: Subject to compliance with requirements, provide one of the following for a typical L5-20R device (if applicable):
 - a. Cooper; CWL520R.

- b. Hubbell; HBL2310.
 - c. Leviton; 2310.
 - d. Pass & Seymour; L520-R.
- 2. Provide all device configurations depicted in Drawings, including but not limited to dryers, ranges and food service equipment.

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 unless noted otherwise, 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; CSB120 (single pole).
 - b. Hubbell; CSB120 (single pole).
 - c. Leviton; 1221-2 (single pole).
 - d. Pass & Seymour; CSB20AC1 (single pole).
- C. Pilot Light Switches, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; AH1221PL for 120 V and 277 V.

- b. Hubbell; HBL1221PL for 120 V and 277 V.
- c. Leviton; 1221-PLR for 120 V, 1221-7PR for 277 V.
- d. Pass & Seymour; PS20AC1RPL for 120 V, PS20AC1RPL7 for 277V.

- 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

2.10 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: 0.035-inch- (1-mm-) thick, satin-finished type 302 stainless steel.

- B. Wet-Location, Weatherproof, While-In-Use Cover Plates: NEMA 250, complying with Type 3R weather-resistant, die-cast aluminum with lockable cover.

- 1. Vertical Mount:

- a. Products: Subject to compliance with requirements, provide one of the following:

- 1) Hubbell; WP26M.
- 2) Intermatic; WP1250MVXD.
- 3) Pass & Seymour; WIUCAST1.

- 2. Horizontal Mount:

- a. Products: Subject to compliance with requirements, provide one of the following:

- 1) Hubbell; WP8MH.
- 2) Intermatic; WP1010HMXD.
- 3) Pass & Seymour; WIUCAST1.

- C. Lockout Wall Plates: Single 302 stainless steel switch cover with integral lockout hasp.

- 1. Products: Subject to compliance with requirements, provide one of the following or approved equal:

- a. Leviton; 84001-LOK.

2.11 INDUSTRIAL CORD REELS

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

- 1. Hubbell Wiring Device - Kellems
- 2. KH Industries

- B. Type CRA Description: 20-amp industrial grade retractable cord reel. Housing shall have yellow finish. #12 AWG black SJO cable, yellow, black, or gray portable outlet box with strain

relief and two back-to-back GFCI duplex receptacles. Reel shall be equipped with 5-foot power supply cord and 20-amp straight blade plug. Length of retractable cable shall be **25-feet** with adjustable ball stop.

1. Product: Subject to compliance with requirements, provide the following or approved equal:
 - a. Hubbell; HBLI25123GF220Y.
 - b. KH Industries; RTBB3L Series.

- C. Type CRB Description: 20-amp industrial grade retractable cord reel. Housing shall have yellow finish. #12 AWG black SJO cable, yellow, black, or gray portable outlet box with strain relief and two back-to-back GFCI duplex receptacles. Reel shall be equipped with 5-foot power supply cord and 20-amp straight blade plug. Length of retractable cable shall be 45- or 50-feet with adjustable ball stop.

1. Product: Subject to compliance with requirements, provide the following or approved equal:
 - a. Hubbell; HBLI45123GF220Y.
 - b. KH Industries; RTBB3L Series.
2. Accessories: Provide pivot base.

2.12 PUSH-BUTTON STATIONS AND BUZZERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. DyanLock.
 2. Edwards Signaling.
- B. Push-button Station: Weather-proof. Features include the following:
 1. Weatherproof diaphragm enclosing the mechanism, with rubber gasket at wall plate.
 2. Flush mount, satin chrome finish.
 3. Contact Rating: 120-volt.
 4. Selecta SS228-BG switch and matching stainless-steel plate, or approved equal.
- C. Buzzer: Heavy-duty, one-piece, surface mount plug-in assembly. Features include the following:
 1. Corrosion-resistant epoxy finish.
 2. Mounting plate plug-in assembly for standard single-gang box.
 3. Device Rating: 120-volt.
 4. Adjustable volume control.
 5. Edwards 340A-N5, or approved equal.

2.13 ROTARY TIMER SWITCHES

- A. Rotary Timer Switches: Spring-wound mechanical in-wall timer switch with auto-off function and no hold feature.
 - 1. Metal time dial plate with screw mounting.
 - 2. Press-on knob.
 - 3. Rating: 20-amp, 120-volt resistive, 1HP at 120-volt AC, 2 HP at 240-volt AC.
 - 4. Single-pole, single throw.
 - 5. 60-minute time cycle RT60: Tork C560M, or approved equal.
 - 6. 2-hour time cycle RT2: Tork C502H, or approved equal.
 - 7. 12-hour time cycle RT12: Tork C512H, or approved equal.

2.14 PILOT LIGHTS

- A. Products: Subject to compliance with requirements, provide one the following or approved equal:
 - 1. Pass & Seymour; 2151-RED for 120/277-volt applications
- B. Description: Neon bulb emits light through transparent lens, illuminated when 120-volt power is "ON". Provide engraved wall plate indicating load served.

2.15 FINISHES

- A. Color: Wiring device catalog numbers in Section text do not designate device color.
 - 1. Wiring Devices: Gray, unless otherwise indicated or required by NFPA 70 or device listing.

2.16 CLEAR PROTECTIVE DEVICE COVER

- A. Continuous piano-style top hinge.
 - 1. Safety Technology International (STI) Model STI-6519, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, unless otherwise noted.
- B. Coordination with Other Trades:

1. Take steps to ensure 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.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtail existing conductors is permitted provided the outlet box is large enough.

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. Receptacle Orientation: Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening. Group adjacent switches under single, multi-gang wall plates.

- G. Labels: Provide a machine printed label on standard outlets with remote GFCI protection.

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. 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 114 to 126 V.
2. Percent Voltage Drop under 15-A Load: A value over 5 percent 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.

END OF SECTION 262726

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SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Cartridge fuses rated 600 V and less for use in switches, switchboards, and controllers.

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.
- B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals.

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 one percent of each fuse type and size, but no fewer than 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. Littelfuse, Inc.
 - 3. Mersen.

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. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Feeders: Class L time delay or Class J time delay.

- B. Motor Branch Circuits: Class RK5 time delay.
- C. Other Branch Circuits: Class RK5 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 262813

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SECTION 262816 - 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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Motor-rated toggle switches.
 - 2. Fusible switches.
 - 3. Nonfusible switches.
 - 4. Molded-case circuit breakers.
 - 5. Enclosures.
 - 6. Elevator Power Switches

1.3 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. 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. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 2. Time-current curves, including selectable ranges for each type of circuit breaker.

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 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.7 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. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MOTOR-RATED TOGGLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB.
 - 2. Eaton Electrical Inc.; Cutler-Hammer Products.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; Schneider Electric.
- B. Manual Switches: Standard toggle switches in surface mounted metallic NEMA enclosure, minimum amperage rating of 20 amps, 1 or 2-pole as required for application.
 - 1. Products: Subject to compliance with requirements, provide the following or approved equal:
 - a. Square D; KG Series.
- C. Optional Feature: Provide with optional features such as keyed switch operation and pilot light where indicated on Drawings.
- D. Boilers/Water Heaters: Toggle switches used as local disconnecting means for boilers shall be capable of being locked in the 'off' position. Provide with handle guard/ lock off option or mount switch in a lockable enclosure and label cover 'BOILER DISCONNECT' or 'WATER HEATER DISCONNECT'.

2.3 FUSIBLE AND NON-FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Corporation; Cutler-Hammer Products.
 - 2. General Electric Co.; Electrical Distribution & Control Division.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D/Group Schneider.
- B. Fusible Switch, 800 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. Nonfusible Switch, 800 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.

2.4 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Corporation; Cutler-Hammer Products.
 2. General Electric Co.; Electrical Distribution & Control Division.
 3. Siemens Energy & Automation, Inc.
 4. Square D/Group Schneider.
- B. Molded-Case Circuit Breaker: NEMA AB 1, 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 magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. GFCI Circuit Breakers: Single- and two-pole configurations with 5 or 30-mA trip sensitivity as indicated on drawings.
- C. Molded-Case Circuit-Breaker Features and Accessories:
1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.
 3. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.
 4. Ground-Fault Protection: integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.

2.5 ELEVATOR POWER SWITCH

- A. Manufacturers:
1. Cooper Bussmann. (PS series)
 2. Littelfuse (LPS series)
 3. Mersen (formerly Ferraz Shawmut) (ES series)
- B. Factory assembled fusible shunt trip switch in NEMA enclosure with all necessary relays, control transformer and options as listed below, as shown on Drawings, and as required to meet functional requirements of local elevator and building codes. Coordinate requirements with elevator equipment supplier and with fire alarm system supplier. Ampere rating shall be per elevator manufacturer requirements and utilize Class J fuses. Features shall include, but not be limited to, the following:
1. Horsepower rated fusible switch with shunt trip capabilities.
 2. 100VA control power transformer with primary and secondary fuses (primary voltage per Drawings, 120 volt secondary).
 3. Fire safety interface relay - 3PDT, 10A, 120V. Coil of isolation relay shall be 120VAC.

4. Fire Alarm System Interface –Isolation relay to activate shunt trip solenoid. Fire alarm system shall control this relay.
5. Options:
 - a. Key to test switch.
 - b. Green 'ON' pilot light.
 - c. Mechanically interlocked auxiliary contact for hydraulic elevators with automatic recall – 1-pole, NC, 5 amp 120VAC rated.
6. Three-pole fire alarm voltage monitor relay (monitors shunt trip voltage).

2.6 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
 1. Outdoor Locations: NEMA 250, Type 3R.
 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 3. Other Wet or Damp 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.

3.3 IDENTIFICATION

- A. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Section 260553 "Identification for Electrical Systems."

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.

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 262816

SECTION 263323 - CENTRAL BATTERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes central battery equipment to provide emergency power to lighting and small ventilation fans.
- B. Related Sections include the following:
 - 1. Section 033000 "Cast-in-Place Concrete" for housekeeping pads.

1.3 DEFINITIONS

- A. LCD: Liquid-crystal display.
- B. LED: Light-emitting diode.
- C. THD: Total harmonic distortion.
- D. UPS: Uninterruptible power supply.

1.4 SUBMITTALS

- A. Product data.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For central battery inverter equipment to include in emergency, operation, and maintenance manuals.

1.6 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. Deliver extra materials to Owner.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.

1.7 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. Central Battery Inverter System: UL 924 listed.
- C. Comply with NFPA 70 and NFPA 101.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver equipment in fully enclosed vehicles.
- B. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

1.9 COORDINATION

- A. Coordinate size and location of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual equipment provided.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
1. Warranty Period: Include the following warranty periods, from date of Substantial Completion:
- a. Full Warranty: One year.
- b. Pro Rata: Nine years.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide a Myer Power Products; Illuminator Series system or equal by one of the following:
1. ABB; Emergi-Lite.
 2. Acuity Brands; Iota Engineering.
 3. Dual-Lite.
 4. Eaton; Sure-Lites Division.
 5. Evenlite.
 6. Isolite.
 7. Liebert.
 8. Myers Power Products, Inc.

2.2 SYSTEM REQUIREMENTS

- A. Voltage: Input and output voltage as listed on the Drawings.
- B. Output Load Capacity: The system shall be able to supply the kVA load indicated on the drawings. The system shall be able to supply the rated kW with power factor ranging from 0.5 lagging to 0.5 leading. Derate units as recommended by the manufacturer for lighting and fan loads.
- C. Surge Protection: System shall include surge protection to allow system to sustain input surges without damage per standards set in ANSI C62.41 and C62.42.45.
- D. Modes of Operation:
1. Normal: The inverter shall be a line interactive standby system. Normal AC power shall continuously supply the load. The input converter (rectifier) derives power from the normal power source to supply the inverter and provide a floating charge to the batteries.
 2. Emergency: Upon failure of the normal power source, the system shall automatically switch within 0.4 seconds to the battery power source.
 3. Recharge: Upon restoration of the normal power source, the system shall automatically switch back to the normal power source and recharge the batteries. Switching may be delayed for up to a minute of sustained normal power to prevent excessive switching during periods of intermittent normal power. Switching shall be accomplished within 0.4 seconds.

2.3 INVERTERS

- A. Description: Solid-state type, with the following operational features:
1. Automatically regulate output voltage to within plus or minus 5 percent.

2. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
3. Output Voltage Waveform of Unit: Sine wave with maximum 10 percent THD throughout battery operating-voltage range, from no load to full load.
 - a. THD may not exceed 5 percent when serving a resistive load of 100 percent of unit rating.
4. Output Protection: Current-limiting and short-circuit protection.
5. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.
6. Normally on monitored output breakers.

2.4 BATTERY SYSTEM

- A. Battery Cells: Sealed, valve regulated, lead acid batteries.
- B. Battery Run-Time: The battery system shall be sized to provide the necessary reserve time to the feed 100% of the load capacity listed on the Drawings for the specified time period. Minimum specified time periods are as follows unless noted otherwise on Drawings:
 1. Units serving FEMA Shelters: 120 minutes.
 2. All other units: 90 minutes.
 3. Recharge Time: The system shall recharge fully discharged batteries within a 24-hour period.
- C. Battery Charger: Solid-state, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes.

2.5 MANUAL TESTING

- A. The system shall incorporate a push to test switch to initiate an inverter test at any time. During this test, a power failure will be simulated and the batteries shall power the connected load through the inverter.

2.6 MAINTENANCE BYPASS SWITCH

- A. The system shall incorporate a maintenance bypass switch.

2.7 ALARMS

- A. An audible alarm shall be provided for all alarm and shutdown conditions.

2.8 ENCLOSURES

- A. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
- B. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.

2.9 INDICATION

- A. Indications: Labeled LEDs.

2.10 OUTPUT DISTRIBUTION

- A. Provide with output breakers as indicated on Drawings.

2.11 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.12 SOURCE QUALITY CONTROL

- A. Factory test complete inverter system, including batteries before shipment.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance.
 - 1. Prior to installation, verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment will be installed.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where equipment will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install system components per manufacturer's recommendations.
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- C. Install wall-mounting equipment level and plumb with wall brackets fabricated by transformer manufacturer.
- D. Construct concrete bases and anchor floor-mounting equipment according to manufacturer's written instructions.

3.3 CONNECTIONS

- A. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
 - 2. Test manual and automatic operational features and system protective and alarm functions.
- C. Remove and replace malfunctioning units and retest as specified above.

3.5 STARTUP SERVICE

- A. Verify that central battery inverter is installed and connected.
- B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
- C. Complete installation and startup checks according to manufacturer's written instructions.

END OF SECTION 263323

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes lightning protection for buildings.
- B. Maintain the lightning protection system for the existing building. Splice, extend, reconfigure existing lightning protection system as required to maintain existing system after construction.
- C. Provide a lightning protection system for the addition that ties into the existing lightning protection system.

1.3 DEFINITIONS

- A. LPI: Lightning Protection Institute.
- B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

- A. Product Data: For air terminals and mounting accessories.
- B. Shop Drawings: Detail lightning protection system, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
- C. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL.
- D. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the roofing material.
- E. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who is an NRTL.
- B. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.6 COORDINATION

- A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
- B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ERICO International Corporation.
 - 2. Harger Lightning Protection, Inc.
 - 3. Heary Bros. Lightning Protection Co. Inc.
 - 4. Independent Protection Co.
 - 5. Robbins Lightning Inc.
 - 6. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. Comply with UL 96.
- B. Roof-Mounting Air Terminals: NFPA Class I, copper or aluminum, solid, unless otherwise indicated.
 - 1. Where air terminals are mounted using adhesive bases, the mounting of the base shall be compatible with roofing membrane and approved by the roof system manufacturer.
- C. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Section 260526 "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to UL 96A and NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.
- C. Conceal the following conductors:
 - 1. Down conductors.
 - 2. Interior conductors.
 - 3. Conductors within normal view from exterior locations at grade within 200 feet (60 m) of building.
 - 4. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.
- D. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above membrane roofing.
- E. Air Terminals on Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- F. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.

3.2 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.
- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL

- A. UL Inspection: Provide inspections as required to obtain a UL Master Label for system.

END OF SECTION 264113

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SECTION 265100 - LIGHTING

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 the following:
 - 1. Lighting fixtures, LED arrays, and drivers.
 - 2. Exterior luminaires mounted on poles, building surfaces or recessed in canopies.
 - 3. Exit signs.
 - 4. Lighting fixture supports.
 - 5. Light poles.
- B. Related Sections include the following:
 - 1. Section 033000 "Cast-in-Place Concrete" for pole bases.
 - 2. Section 260923 "Lighting Controls" for automatic control of lighting, including network bridges, room controllers, occupancy and vacancy sensors, and exterior lighting control systems.
 - 3. Section 262726 "Wiring Devices" for line-voltage manual control of lighting.

1.3 DEFINITIONS

- A. CRI: Color-rendering index.
- B. CU: Coefficient of utilization.
- C. LED: Light Emitting Diode
- D. LER: Luminaire efficacy rating.
- E. Luminaire: Complete lighting fixture, including LED light engine array and driver, and housing.
- F. RCR: Room cavity ratio.

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. Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4.
- C. 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 50 feet (15 m) or less in height is 90 mph (145 km/h).

1.5 DELIVERY, STORAGE, AND HANDLING OF POLES

- A. 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.
- B. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.6 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 lighting fixture including dimensions and spacing-to-mounting-height ratio.
 - 2. Energy efficiency data.
 - 3. LED drivers, including projected driver life and current.
 - 4. Lamps and LED arrays: include life, lumen output, CRI and color temperature for each type.
 - 5. Photometric data, in IESNA format, based on laboratory tests of each lighting fixture type, outfitted with LED arrays, drivers, and accessories identical to those indicated for the lighting fixture as applied in this Project. Upon request, provide electronic photometric data in IESNA format.
 - 6. Physical properties of light poles, including height, wall thickness, finishes and accessories.
- B. Field quality-control test reports.
- C. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.
- D. Warranties: Special warranties specified in this Section.

1.7 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.

1.8 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.

1.9 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. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.

1.10 WARRANTIES

- A. LED Light Fixtures Warranty: Minimum of five years on drivers, emergency drivers and LED arrays.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In the Light Fixture Schedule, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, where multiple manufacturers are listed, provide products by one of the manufacturers specified herein or listed in the Light Fixture Schedule.
 - 2. Basis of Design Products: Where a single manufacturer is listed, the design of the interior luminaire and its support is based on the listed product. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other listed manufacturers, or equal.
 - 3. Fixtures must meet requirements noted on drawings and specified below.
- B. LED Drivers: Subject to compliance with requirements, provide products by one of the following:

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

- a. GE Lighting: Formerly Lightech.
- b. Philips Lighting Electronics North America Corporation: Philips Advance.

- C. LEDs: Subject to compliance with requirements, provide products by one of the following:

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

- a. Cree, Inc.
- b. GE Lighting – Lightech.
- c. Nichea Corporation.
- d. Philips Lighting Electronics North America Corporation (Philips LumiLEDs).

2.2 LED LIGHT FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

- A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.
- B. Remote phosphor technology or exposed LED array.
- C. LLM at 70-percent output: 50,000 hours, unless noted otherwise in Light Fixture Schedule.
- D. Efficacy, Color Temperature and CRI: Refer to Light Fixture Schedule for minimum requirements.
- E. Metal Parts: Free of burrs and sharp corners and edges.
- F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

2.3 LED DRIVERS

- A. Performance characteristics:
 1. Class I electronic driver.
 2. Power factor: >90%.
 3. Total harmonic distortion: THD <20%.
 4. Expected life: 100,000 hours with <1% failure rate.
 5. Drive current: Refer to Light Fixture Schedule.
 6. Refer to Light Fixture Schedule for specific driver requirements.

2.4 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.

2.5 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Section 260529 "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Suspended direct/indirect and direct fixtures in finished space: Suspend fixtures with manufacturer's standard aircraft cable system unless noted otherwise. Feed fixtures with manufacturer's standard SO cable.
- C. Suspended industrial strips in unfinished spaces: Suspend fixtures with chains unless noted otherwise.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gages (2.68 mm).
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gages (2.68 mm).
- F. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

2.6 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4.
 1. 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.
 2. 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.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts, unless otherwise indicated.
- C. Mountings, Fasteners, and Accessories: 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.

4. Metallic Pole Base Cover: Designed to cover and protect anchor bolts, finish to match pole.
- D. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

2.7 STEEL POLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Acuity Brands, Inc.
 2. Eaton.
 3. Gardco.
 4. KW Industries.
 5. Signify (Philips Gardco).
 6. Valmont.
- B. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 42,000 psig (317 MPa); 1-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
 1. Shape: See Light Fixture Schedule.
 2. Gauge:
 - a. Poles 30-feet high or less shall be 4-inch round, 11-gauge.
 3. Vibration dampener: Provide dampener for all poles 25-feet high or more.
 4. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
 5. Accessories: Provide pole base cover, finish to match pole and fixture heads.
- C. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as pole.
- D. Brackets for Luminaires: Detachable, cantilever, without underbrace.
 1. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 3. Match pole material and finish.
- E. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "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.
- F. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

- G. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "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. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
 3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As indicated on Light Fixture Schedule

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Lighting fixtures: Set level, plumb, and square with ceilings and walls.
- B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Do not use grid as a support element.
1. Install ceiling support system wires at a minimum of 2 wires connected directly to each fixture, located not more than 6 inches (150 mm) from opposite fixture corners. Provide additional supports if required by local code or the local authority having jurisdiction.
 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.
 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 (20-mm) metal channels spanning and secured to ceiling tees.
 4. Where a suspended fixture attaches to a ceiling grid, provide a ceiling support system wire from structure above and connect directly to each fixture support component.
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery, inverter or generator and retransfer to normal.

END OF SECTION 265100

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SECTION 270500 - COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

- A. The purpose of this section is to provide general guidelines, required standards and documentation, and other considerations related to the Division 27 in its entirety. This section will be referred to in subsequent sections for this division and others.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, Division 07, and Division 08 Specification Sections, apply to this Section.
- B. Drawings and provisions of the Contract including Division 26 Electrical.

1.3 SUBMITTALS AND SHOP DRAWINGS

- A. Refer to Division 1 and the General Provisions of the Contract for exact submittal procedures.
- B. Work shall not proceed without OWNER and Technology Consultant approval of all submitted items.
- C. Shop drawings shall be submitted in advance of construction so as to cause no delay in other Contractors' work. Shop drawings shall be submitted at such time to allow the Engineer reasonable time to review shop drawings to make necessary corrections.
- D. It will be assumed that the Contractor has examined the shop drawings and equipment brochures prior to submission and that materials and equipment depicted will readily fit into the construction. Contractor shall also review all completed work related to materials or equipment depicted to ensure that it has been properly installed.
- E. No materials or equipment subject to prior review by the Engineer shall be fabricated or installed by the Contractor, without such review and approval. The Engineer's review of such drawings and brochures shall not relieve the Contractor of responsibility for deviations from the requirements of the drawings and specifications, unless he has notified the Engineer in writing.
- F. The Division 27 Contractor shall provide for review, without exception prior to material acquisition and installation, multiple copies of the following items, quantity as required by the General Contractor or Construction Manager, as applicable. Specific requirements shall be listed and described within each Division 27 section. Failure to submit required items shall disqualify the bidder.

- 1. Product Data Sheets (Catalog Cuts)

2. Backbone/Riser/Cabling Diagrams
 3. System Schematics
 4. Specification Sheets for Test Equipment
 5. Bill of Materials
 6. Contracting Firm Qualifications and Certifications
 7. Installation Team Qualifications by Individual
 8. Current Manufacturer Certifications
- G. The Division 27 Contractor shall provide Coordination Drawings for review, without exception prior to material acquisition and installation for approval to proceed. Coordination Drawings shall consist of floor plans and building sections, drawn to scale. Include scaled Cable Tray/Runway layout and relationships between components and adjacent structural and mechanical elements. Show the following:
1. Vertical and horizontal offsets and transitions.
 2. Clearances for access above and to the side of Cable Tray/Runways.
 3. Vertical elevation of Cable Tray/Runways above floor or bottom of ceiling structure.
- H. Provide throughout installation:
1. Material samples, if requested by the Architect, Technology Consultant, General Contractor, or Construction Manager.
 2. Periodic field quality control reports.
 3. Periodic cable test reports.
- I. Provide prior to completion:
1. Actual samples of the component labeling scheme to be applied to cabling components, to be approved by the Architect, Technology Consultant, General Contractor, or Construction Manager.
 2. Draft cable administration drawings, as requested to assist OWNER in the planning process. Drawings will be requested prior to final documentation and as Xerox reproductions of hand written field copies.
- J. Provide at completion of each construction/testing phase or area, as defined by the General Contractor or Construction Manager:
1. Cable test and certification reports; summary hard copy or full test results via digital file share or USB drive when requested by the General Contractor or Construction Manager, OWNER Networking & Telecommunications, or the Technology Consultant. Reports shall be submitted to the requesting party within thirty (30) working days of completion for each phase.
 2. One (1) full size set of final drawings of the actual installation for the Division 27 systems. Drawings shall be given as D or E size originals and on disc or USB drive in AutoCAD format.
- K. Provide after the installation is complete

1. One (1) full size set of record drawings of the actual installation for the Division 27 systems. Drawings shall be given as D or E size originals and on disc or USB drive in AutoCAD format.
- L. Provide after the installation is complete and two (2) weeks before final acceptance, three (3) bound sets of O&M (Operating and Maintenance) Manuals formatted as defined by Division 1 and within Section 270000. In addition to the specific requirements contained within each Division 27 sub-section, each copy of the O&M Manual shall include, at minimum, items listed as follows:
 1. One (1) copy of each approved submittal.
 2. Cable test and certification reports; summary hard copy and full test results on disc or USB drive.
 - a. All test data, including documentation of failed tests, the corrective procedures performed, and the results of re-tests are to be documented and submitted in both hard copy and ASCII format on CD-ROM disc.
 - b. Hand written test reports shall not be accepted.
 - c. All actions required to correct failed tests shall be documented to include the cable identifier, tests that were failed, and actions performed to correct the problem.
 3. Instruction manuals including equipment and cable schedules, operating instructions, and manufacturer's instructions.
 4. Manufacturer Warranty Certificate.
 5. Warranty contacts including but not limited to: names and telephone numbers (office and mobile).

1.4 CODE AND STANDARDS

- A. All work shall be in compliance with all applicable codes and regulations. Nothing contained within these Specifications shall be misconstrued to permit work not in conformance with the most stringent of applicable codes and standards. It is assumed that bidders have access to, and specific knowledge of, these reference materials in order to ensure conformity with them.
- B. Refer to Division 1 – Reference Standards and General Conditions of the Contract

1.5 SITE ACCESS AND CONDITIONS

- A. This is an existing building that this Owner is moving into. Protect all existing equipment to be reused. Whenever possible every attempt should be made to reuse existing equipment.

1.6 COORDINATION WITH OTHER TRADES

- A. Coordinate layout of work with other trades. Make minor adjustments in location required for coordination. Locations of structural systems, heating work and plumbing lines shall take preference over locations of conduit lines where conflict occurs. Structural systems, heating work, and plumbing lines shall not interfere with or otherwise impede the routing of

communication cabling with cable tray, raceways, or other pathways dedicated to communications. All potential issues shall be brought to the attention of the General Contractor or Construction Manager immediately, before proceeding with installation.

- B. Other than minor adjustments shall be submitted to the General Contractor or Construction Manager for approval before proceeding with the work.
- C. Coordinate locations, arrangement, mounting, and support of all communications provisions with Division 26.
 - 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 that connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- D. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 and Division 26
- F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08.
- G. The location of TO(s) and WAO(s) shown on the Drawings is approximate, and the General Contractor or Construction Manager shall have the right to relocate any TO(s) or WAO(s) before they are installed without additional cost.

PART 2 - PRODUCTS

2.1 WARRANTY

- A. Provide warranties as required by subsequent sections of this division. Documents verifying the duration, included services and maintenance, and the contractor's ability to provide the warrantied installation and maintenance, shall be provided prior to the start of installation.

PART 3 - EXECUTION

3.1 FIELD CONDITIONS

- A. Examine all elements intended for Communications. Check pathways, raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, installation hazards or impediments, and other conditions affecting installation. Verify that all work

required in the field is adequately described in the plans. Proceed with installation only after unsatisfactory conditions and discrepancies have been brought to the attention of the General Contractor or Construction Manager and corrected.

- B. Unless otherwise noted, the footages for cabling and materials shown on the Project Drawings are based upon available plant records, architectural drawings, or the Engineer's route and pathway assumptions. The Contractor shall be required to perform field surveys and measurements, prior to ordering materials.

3.2 COMMON INSTALLATION REQUIREMENTS

- A. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall mounting items.
- B. 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.
- C. 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.
- D. Right of Way: Give to piping systems installed at a required slope.
- E. The Contractor shall contact Owner before commencement of work and shall coordinate with Owner personnel and all other trades. Commencement of work shall be coordinated through the General Contractor or Construction Manager.

3.3 FIRESTOPPING

- A. Verify that openings are ready to receive the Work of this Section.
- B. All conduits, sleeves, and penetrations of fire-rated walls, into which communications cables are pulled or reserved for communications cables, shall be sealed with an approved fire-retardant method and materials in accordance with UL (Underwriters Laboratory Inc.) Fire Resistance Directory.
- C. All openings provided shall be fire stopped after cabling has been installed whether filled, partially filled, or un-used.
- D. Preparation
 - 1. Surface Cleaning: Clean out openings and joints immediately prior to installing firestopping to comply with recommendations of firestopping manufacturer and the following requirements:
 - a. Remove all foreign materials from surfaces of opening and joint substrates and from penetrating items that could interfere with adhesion of firestopping.

- b. Clean opening and joint substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with firestopping. Remove loose particles remaining from cleaning operation.
 - c. Remove laitance and form release agents from concrete.
2. Priming: Prime substrates where recommended by firestopping manufacturer using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.
3. Masking Tape: Use masking tape to prevent firestopping from contacting adjoining surfaces that will remain exposed upon completion of Work and that would otherwise be permanently stained or damaged by such contact or by cleaning methods used to remove smears from firestopping materials. Remove tape as soon as it is possible to do so without disturbing firestopping's seal with substrates.

E. Installing Through-Penetration Firestops

1. Regulatory Requirements: Install penetration seal materials in accordance with published "Through-Penetration Firestop Systems" in UL's Fire Resistance Directory.
2. Install forming/damming materials and other accessories of types required to support fill materials during their application and in the position needed to produce the cross-sectional shapes and depths required to achieve fire ratings of designated through-penetration firestop systems. After installing fill materials, remove combustible forming materials and other accessories not indicated as permanent components of firestop systems.
3. Install fill materials for through-penetration firestop systems by proven techniques to produce the following results:
4. Completely fill voids and cavities formed by openings, forming materials, accessories, and penetrating items.
5. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
6. For fill materials that will remain exposed after completing Work, finished to produce smooth, uniform surfaces that are flush with adjoining finishes.

F. Field Quality Control

1. Where deficiencies are found, repair or replace firestopping so that it complies with requirements.
2. Keep areas of work accessible until inspection by applicable code authorities.
3. Perform under this Section, patching and repairing of firestopping caused by cutting or penetrating by other trades.

G. Adjusting and Cleaning

1. Remove equipment, materials and debris, leaving area in undamaged, clean condition.
2. Neatly cut and trim materials as required.
3. Clean off excess fill materials and sealants adjacent to openings and joints as work progresses by methods and with cleaning materials approved by manufacturers of firestopping products and of products in which opening and joints occur.

H. Protection of Finished Work

1. Protect firestopping during and after curing period from contact with contaminating substances or form damage resulting from construction operations or other causes so that they are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated firestopping immediately and install new materials to produce firestopping complying with specified requirements.

END OF SECTION 270500

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SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. The purpose of this section is to provide direction on the grounding and bonding requirements for systems covered by this division. This section will be referred to in subsequent sections of this division and others.
- B. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.
 - 4. Grounding rods.
 - 5. Grounding labeling.

1.2 RELATED DOCUMENTS

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-C.

2.2 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Harger Lightning & Grounding.
 - 2. Panduit Corp.
 - 3. TE Connectivity Ltd.
- B. Comply with UL UL 486A-486B.

- C. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the PBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
- D. Underground Grounding Conductors:
 - 1. Install bare copper conductor, No. 2 AWG minimum.
- E. Grounding Electrode System:
 - 1. The BCT between the PBB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.
- F. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. If cable tray contains electrical power conductors, then NFPA 70, Article 392 "Cable Trays" governs, and the minimum equipment grounding conductor size is No. 4 AWG.
 - 3. Cable Tray Equipment Grounding Wire: No. 6 AWG.
- G. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Tinned Conductors: ASTM B33.
 - 4. Sizes and types of conductors in three subparagraphs below are typical examples. 28-kcmil (14.2-sq. mm) bonding cable in "Bonding Cable" Subparagraph is slightly larger than No. 6 AWG.
 - a. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
 - b. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - c. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Chatsworth Products, Inc.
 - 2. Harger Lightning & Grounding.

B. Terminations and Connections: TIA-232

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

C. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.

D. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.

1. Electroplated tinned copper, C and H shaped.

E. Signal Reference Grid Connectors: Combination of compression wire connectors, access floor grounding clamps, bronze U-bolt grounding clamps, and copper split-bolt connectors, designed for the purpose.

F. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.

G. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 JUMPERS

A. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.
2. Not smaller than No. 10 AWG and not longer than 12 inches. If jumper is a wire, it shall have a crimped grounding lug with one hole and standard barrel for one crimp. If jumper is a flexible braid, it shall have a one- or two-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

2.5 GROUNDING BUSBARS

A. PBB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as PBB and shall comply with TIA-607-C.

1. Predrilling shall be with holes for use with lugs specified in this Section.

2. In "Mounting Hardware" Subparagraph below, the minimum required clearance is 2 inches (50 mm). 4 inches (100 mm) is typical in the industry. Indicate busbar length on Drawings.
 3. Mounting Hardware: Stand-off brackets that provide a 4-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 4. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- B. SBB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-C.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-C. Predrilling shall be with holes for use with lugs specified in this Section.
1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19 inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 3. Rack-Mounted Vertical Busbar: 72 inch long, with stainless-steel hardware for attachment to the rack.

2.6 GROUND RODS

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in diameter.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.

- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-C.
- D. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Support at not more than 36-inch intervals.
 - 4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
- E. Cable Basket and Trays:
 - 1. Ground cable trays according to NFPA 70 unless additional grounding is specified.
 - 2. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
 - 3. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."
 - 4. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.
 - 5. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."
- F. Grounding Busbars
 - 1. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, 12 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

G. Conduit Chase Pipes:

1. Furnish and install 4" EMT conduit "Chase Pipes" within the TR and other information transport system spaces where communications cabling must pass through suspended ceiling tiles enroute to point of cabling termination.
2. Chase Pipes shall be securely mounted to the wall above Cable Runway segments using slotted unistrut and 4" pipe clamps. Reamed and bush pipes at both ends prior to cabling rough-in.

H. Connections:

1. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
2. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
3. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:
 - a. Use crimping tool and the die specific to the connector.
 - b. Pre-twist the conductor.
 - c. Apply an antioxidant compound to all bolted and compression connections.
4. Primary Protector: Bond to the PBB with insulated bonding conductor.
5. Interconnections: Interconnect all SBBs with the PBB with the telecommunications backbone conductor. If more than one PBB is installed, interconnect PBBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.
6. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the SBB No. 2 AWG bonding conductors.
7. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
8. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each SBB to the ground bar of the panelboard.
9. Shielded Cable: Bond the shield of shielded cable to the SBB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded balanced twisted-pair cables.
10. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
11. Access Floors: Bond all metal parts of access floors to the SBB.
12. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.

- a. Install the conductors in grid pattern on 4-foot centers, allowing bonding of one pedestal from each access floor tile.
- b. Bond the SBB of the equipment room to the reference grid at two or more locations.
- c. Bond all conduits and piping entering the equipment room to the SBB at the perimeter of the room.

13. Towers and Antennas:

- a. Ground Ring: Buried at least 30 inches below grade and at least 24 inches from the base of the tower or mounting.
- b. Bond each tower base and metallic frame of a dish to the ground ring, buried at least 18 inches below grade.
- c. Bond the ground ring and antenna grounds to the equipment room PBB or SBB, buried at least 30 inches below grade.
- d. Bond metallic fences within 6 feet of towers and antennas to the ground ring, buried at least 18 inches below grade.
- e. Special Requirements for Roof-Mounted Towers:
 - 1) Bond tower base footings steel, the SBB in the equipment room, and antenna support guys to the roof ring.
 - 2) Connect roof ring to the perimeter conductors of the lightning protection system.
- f. Waveguides and Coaxial Cable:
 - 1) Bond cable shields at the point of entry into the building to the SBB and to the cable entrance plate, using No. 2 AWG bonding conductors.
 - 2) Bond coaxial cable surge arrester to the ground or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

I. Grounding Underground Distribution System Components

1. Duct-Bank Grounding Conductor: Bury 12 inches above duct bank when indicated as part of duct-bank installation.
2. Comply with IEEE C2 grounding requirements.
3. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches extends above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.
4. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect grounding conductors to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

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END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. The purpose of this section is to provide direction on productions and installation practices to be used for the low-voltage pathways systems, including cable trays, sleeves, penetrations, and hangers and supports.
- B. Section Includes:
 - 1. Tray:
 - a. Ladder cable tray.
 - b. Wire-mesh cable tray.
 - 2. Hangers and Supports:
 - a. Steel slotted support systems for communication raceways.
 - b. Aluminum slotted support systems for communication raceways.
 - c. Nonmetallic slotted support systems for communication raceways.
 - d. Conduit and cable support devices.
 - e. Support for conductors in vertical conduit.
 - f. Structural steel for fabricated supports and restraints.
 - g. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - h. Fabricated metal equipment support assemblies.
 - 3. Sleeves and Slots:
 - a. Sleeves for pathway and cable penetration of non-fire-rated construction walls and floors.
 - b. Sleeve-seal systems.
 - c. Sleeve-seal fittings.
 - d. Grout.
 - e. Silicone sealants.

1.2 RELATED DOCUMENTS

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

PART 2 - PRODUCTS

2.1 TRAY

A. Performance Requirements

1. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 - a. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

B. General Requirements For Cable Trays

1. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 - a. Source Limitations: Obtain cable trays and components from single manufacturer.
2. Sizes and Configurations: See the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
3. Structural Performance: See articles for individual cable tray types for specific values for the following parameters.
 - a. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 - b. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 - c. Load and Safety Factors: Applicable to both side rails and rung capacities.

C. Ladder Cable Tray

1. For use within Telecommunication / Equipment Room for distribution of telecommunications cabling.
2. Description:
 - a. Manufacturer: Chatsworth (CPI), Hoffman or approved alternate.
 - b. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
 - c. Width: 12 inches unless otherwise indicated on Drawings.
 - d. Minimum Usable Load Depth: 4 inches.
 - e. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
 - f. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
 - g. No portion of the rungs shall protrude below the bottom plane of side rails.
 - h. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
 - i. Fitting Minimum Radius: 24 inches.

D. Wire-Mesh Cable Tray

1. For use in main corridor pathway as required for high cable quantities.
2. Description:
 - a. Manufacturer: Chatsworth (CPI), Cablofil or approved alternate.
 - b. Configuration: Steel wire mesh, complying with NEMA VE 1.
 - c. Width: 10 inches unless otherwise indicated on Drawings.
 - d. Minimum Usable Load Depth: 2 inches.
 - e. Include a opaque bottom liner / tray insert to hide the cabling from view below in any locations where cable tray is not hidden by a 100% opaque ceiling. Note there are several locations in this project with ceiling grid that is not receiving ceiling tile, where would require this application.
 - f. Structural Performance: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a 200-lb concentrated load, when tested according to NEMA VE 1.
 - g. Class Designation: Comply with NEMA VE 1, Class 12AA.
 - h. Splicing Assemblies: Bolted type using serrated flange locknuts.
 - i. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

E. Cable Tray Accessories

1. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
2. Barrier Strips: Same materials and finishes as for cable tray.
3. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.2 HANGERS AND SUPPORTS

A. Performance Requirements

1. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame Rating: Class 1.
 - b. Self-extinguishing according to ASTM D635.

B. Hangers And Supports:

1. Approved Manufacturers:
 - a. Cooper B-Line
 - b. Erico/Caddy
 - c. Panduit Corporation

C. Support, Anchorage, And Attachment Components

1. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.

- a. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - b. Material for Channel, Fittings, and Accessories: Plain steel.
 - c. Channel Width: Selected for applicable load criteria.
 - d. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - e. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - f. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - g. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - h. Channel Dimensions: Selected for applicable load criteria.
2. Conduit and Cable Support Devices: Steel and malleable-iron clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.
3. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications 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 made of malleable iron.
4. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
5. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - a. Verify suitability of fasteners in "Powder-Actuated Fasteners" Subparagraph below for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick.
 - b. Powder-Actuated Fasteners: Threaded-steel stud for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - c. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - d. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - e. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - f. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A325.
 - g. Toggle Bolts: All-steel springhead type.
 - h. Hanger Rods: Threaded steel.

D. Fabricated Metal Equipment Support Assemblies

1. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

2.3 SLOTS AND SLEEVES

A. Sleeves

1. Wall Sleeves:

- a. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- b. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

2. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

B. Sleeve-Seal Systems

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
 - a. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - b. Pressure Plates: Carbon steel.
 - c. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

C. Sleeve-Seal Fittings

1. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

D. Conduit Chase Pipes

1. Conduit Chase Pipes shall be provided within TR spaces in any case where ceiling tile has been provided and must be breached.
2. Electrical Metallic Tubing (EMT) and Fittings
 - a. 4" trade size
 - 1) Manufactured to ANSI C80.3 (EMT Zinc Coated)
 - 2) UL 797 (EMT – Steel)

E. Grout

1. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
2. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

4. Packaging: Premixed and factory packaged.

F. Silicone Sealants

1. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - a. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
2. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.

2.4 WARNING SIGNS

- A. Lettering: 1-1/2-inch- high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

PART 3 - EXECUTION

3.1 CABLE TRAY

A. Cable Tray Installation

1. Install cable trays according to NEMA VE 2.
2. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
3. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
4. Remove burrs and sharp edges from cable trays.
5. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.
6. Fasten cable tray supports to building structure.
7. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
8. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
9. Support bus assembly to prevent twisting from eccentric loading.
10. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
11. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
12. Support wire-basket cable trays with center support hangers, trapeze hangers, or wall brackets.

13. Support center support hangers or trapeze hangers for wire-basket trays with rods sized for the load.
14. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
15. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
16. Make changes in direction and elevation using manufacturer's recommended fittings.
17. Make cable tray connections using manufacturer's recommended fittings.
18. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
19. Install cable trays with enough workspace to permit access for installing cables.
20. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
21. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
22. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
23. Install warning signs in visible locations on or near cable trays after cable tray installation.

B. Connections

1. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
2. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.2 HANGERS AND SUPPORTS

A. Application

1. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - a. NECA 1.
 - b. NECA/BICSI 568.
 - c. TIA-569-D.
 - d. NECA 101.
 - e. NECA 102.
 - f. NECA 105.
 - g. NECA 111.
2. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

3. 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.
4. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

B. Support Installation

1. Raceway Support Methods: In addition to methods described in NECA 1, EMT IMC and RMC may be supported by openings through structure members, according to NFPA 70.
2. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
3. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - a. To Wood: Fasten with lag screws or through bolts.
 - b. To New Concrete: Bolt to concrete inserts.
 - c. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - d. To Existing Concrete: Use expansion anchor fasteners.
 - e. Instead of expansion anchors, powder-actuated-driven threaded studs, provided with lock washers and nuts, may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69 Spring-tension clamps.
 - g. To Light Steel: Sheet metal screws.
 - h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
4. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

C. Installation Of Fabricated Metal Supports

1. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor communications materials and equipment.
2. Field Welding: Comply with AWS D1.1/D1.1M.

D. Painting

1. 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.
 - a. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.3 SLOTS AND SLEEVES

A. Sleeve Installation For Non-Fire-Rated Electrical Penetrations

1. Comply with NECA 1.
2. Comply with NEMA VE 2 for cable tray and cable penetrations.
3. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - a. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - 1) Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - c. Size pipe sleeves to provide [1/4-inch (6.4-mm)] annular clear space between sleeve and pathway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 - d. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - e. Install sleeves for floor penetrations. Extend sleeves installed in floors [2 inches (50 mm)] above finished floor level. Install sleeves during erection of floors.
4. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - a. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - b. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
5. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
6. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron 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.

7. Underground, Exterior-Wall and Floor 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 sleeve-seal system.

B. Sleeve-Seal-System Installation

1. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
2. Install 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.

C. Sleeve-Seal-Fitting Installation

1. Install sleeve-seal fittings in new walls and slabs as they are constructed.
2. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
3. Secure nailing flanges to concrete forms.
4. Using grout, seal the space around outside of sleeve-seal fittings.

END OF SECTION 270528

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 ACTION SUBMITTALS

A. Identification Schedule:

1. Outlets: Scaled drawings indicating location and proposed designation.
2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
3. Racks: Scaled drawings indicating location and proposed designation.
4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and TIA-606-B.
- B. Comply with ANSI Z535.4 for safety signs and labels.
- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 1. Black letters on a white field.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

- B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) thick, polyester flexible labels with acrylic pressure-sensitive adhesive.
 - 1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating protective shields over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
 - 2. Marker for Labels: Permanent, waterproof black ink marker recommended by tag manufacturer.
 - 3. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
 - b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
 - c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

- A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.

2.5 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
 - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - 3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- B. Color and Printing:
 - 1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
 - 2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE" .

2.6 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
 - 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. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
 - 5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- H. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
 - 3. Provide label 6 inches (150 mm) from cable end.
- I. Snap-Around Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches (150 mm) from cable end.
- J. Self-Adhesive Wraparound Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches (150 mm) from cable end.
- K. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
- L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [or concrete envelope] exceeds 16 inches (400 mm) overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- C. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:
1. Wiring closet designation.
 2. Colon.
 3. Faceplate number.
- D. Equipment Room Labeling:
1. Racks, Frames, and Enclosures: Identify front and rear of each with self-adhesive labels containing equipment designation.
 2. Patch Panels: Label individual rows in each rack, starting at top and working down, with self-adhesive labels and label individual rows and outlets, starting at to left and working down, with self-adhesive labels.
 3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
 - a. Room number being served.
 - b. Colon.
 - c. Faceplate number.
- E. Backbone Cables: Label each cable with a vinyl-wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.

- F. Horizontal Cables: Label each cable with a vinyl-wraparound label indicating the following, in the order listed:
 - 1. Room number.
 - 2. Colon.
 - 3. Faceplate number.
- G. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
- H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.
 - 1. Apply to exterior of door, cover, or other access.

3.4 COPPER

- A. Identify system components, wiring, and cabling complying with TIA-606-B.
 - 1. Administration Class: Class 1, Class 2, Class 3, and Class 4.
 - 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3, and Class 4 level of administration, including optional identification requirements of this standard.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. Cable and Wire Identification:
 - 1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
 - 4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.

- a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
 - b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.5 FIBER CABLE

- A. Identify system components, wiring, and cabling complying with TIA-606-B.
 1. Administration Class: Class 1, Class 2, Class 3, and Class 4.
 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA-606-B for Class 2, Class 3, and Class 4 level of administration, including optional identification requirements of this standard.
- C. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- D. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone and entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. Cable and Wire Identification:
 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 4. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- F. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606-B, for the following:
1. Flexible vinyl or polyester that flexes as cables are bent.
- G. Grounding: Labels shall be preprinted or computer-printed type.
1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.
 3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

END OF SECTION 270553

SECTION 271000 - STRUCTURED CABLING

PART 1 - PART 1 GENERAL

1.1 SUMMARY

- A. The purpose of this section is to provide direction for the products and installation practices for the structured cabling system, including horizontal cabling, fiber optic and copper backbone cabling, and unbalanced cabling.
- B. Section Includes:
 - 1. Category 6 twisted pair cable.
 - 2. Twisted pair cable hardware, including plugs, jacks, patch panels, and cross-connects.
 - 3. 62.5/125 micrometer multi-mode, indoor-outdoor optical fiber cable (OM1)
 - 4. Optical fiber cable connecting hardware, patch panels, and cross-connects.

1.2 RELATED DOCUMENTS

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

1.3 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
 - 1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment or in the horizontal cross-connect.

1.4 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

- A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Horizontal Cabling
 - 1. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
 - 2. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
 - 3. Grounding: Comply with TIA-607-C.
- B. Fiber Backbone Cabling
 - 1. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
 - 2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - a. Flame-Spread Index: 25 or less.
 - b. Smoke-Developed Index: 50 or less.
 - 3. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
 - 4. Grounding: Comply with TIA-607-C.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications, Plenum Rated: Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway.
 - 2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - 3. Communications, Non-plenum: Type CMR complying with UL 1666.

4. Communications, Non-plenum: Type CMP or Type CMR in listed plenum or riser communications raceway.
 5. Communications, Non-plenum: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
1. Flame-Spread Index: 25 or less.
 2. Smoke-Developed Index: 50 or less.
- C. RoHS compliant.

2.3 HORIZONTAL CABLE AND CONDUCTORS

- A. Category 6 Twisted Pair Cable
1. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.
 2. Approved Manufacturers:
 - a. Commscope
 3. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
 4. Conductors: 100-ohm, 23 AWG solid copper.
 5. Shielding/Screening: Unshielded twisted pairs (UTP).
 6. Cable Rating: Plenum.
 7. Jacket: Blue thermoplastic.

2.4 FIBER OPTIC BACKBONE CABLE AND CONDUCTORS

- A. 62.5/125 Micrometer, Multi-Mode, Indoor-Outdoor Optical Fiber Cable (OM1)
1. Description: Multi-mode, 62.5/125-micrometer, 12 fibers, single loose tube, unarmored optical fiber cable.
 2. Approved Manufacturers:
 - a. Commscope
 3. Standards:
 - a. Comply with TIA-492CAAB for detailed specifications.
 - b. Comply with TIA-568-C.3 for performance specifications.
 - c. Comply with ICEA S-104-696 for mechanical properties.
 4. Armored cable shall be steel or aluminum armored type.

5. Maximum Attenuation: 0.5 dB/km at 1310 nm; 0.5 dB/km at 1550 nm.
6. Jacket:
 - a. Jacket Color: Black.
 - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
 - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.
7. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - a. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
 - b. Plenum Rated, Nonconductive: Type OFNP in listed plenum communications raceway.
 - c. Plenum Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit.
 - d. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFN, Type OFNG, Type OFNP, or Type OFNR in metallic conduit.
 - e. Riser Rated, Nonconductive: Type OFNR or Type OFNP, complying with UL 1666.
 - f. Riser Rated, Nonconductive: Type OFNP or Type OFNR in listed riser or plenum communications raceway.
 - g. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - h. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
 - i. Plenum Rated, Armored (Conductive): Type OFCP or Type OFNP in listed plenum communications raceway.
 - j. Plenum Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
 - k. Riser Rated, Armored (Conductive): Type OFCR or Type OFCP; complying with UL 1666 and ICEA S-103-701.
 - l. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, or Type OFCR or Type OFNP in listed riser or plenum communications raceway.
 - m. Riser Rated, Armored (Conductive): Type OFCP, Type OFNP, Type OFCR, or Type OFNR in metallic conduit.

2.5 CONNECTORS

A. Balanced Twisted Pair Cable Hardware

1. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
2. Approved Manufacturers:
 - a. Commscope Systimax
3. General Requirements for Twisted Pair Cable Hardware:

- a. Comply with the performance requirements of Category 6.
 - b. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 - c. Cables shall be terminated with connecting hardware of same category or higher.
4. Jacks and Jack Assemblies:
 - a. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - b. Designed to snap-in to a patch panel or faceplate.
 - c. Standard: Comply with TIA-568-C.2.
 - d. Marked to indicate transmission performance.
5. Plugs and Plug Assemblies:
 - a. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - b. Standard: Comply with TIA-568-C.2.
 - c. Marked to indicate transmission performance.
6. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.

B. Optical Fiber Cable Hardware

1. Approved Manufacturers:
 - a. Commscope Systimax
2. Standards:
 - a. Comply with Fiber Optic Connector Intermateability Standard (FOCIS) specifications of the TIA-604 series.
 - b. Comply with TIA-568-C.3.
3. Connector Type: Type LC complying with TIA-604-10-B connectors.
4. Plugs and Plug Assemblies:
 - a. Male; color-coded modular telecommunications connector designed for termination of a single optical fiber cable.
 - b. Insertion loss not more than 0.75 dB.
 - c. Marked to indicate transmission performance.
5. Jacks and Jack Assemblies:
 - a. Female; quick-connect, simplex and duplex; fixed telecommunications connector designed for termination of a single optical fiber cable.
 - b. Insertion loss not more than 0.75 dB.

- c. Marked to indicate transmission performance.
- d. Designed to snap-in to a patch panel or faceplate.

2.6 PATCHING AND CROSS CONNECTIONS

A. Copper

- 1. Approved Manufacturers:
 - a. Commscope Systimax
- 2. Patch Cords: Factory-made, four-pair cables in 5 and 7-foot lengths; terminated with an eight-position modular plug at each end.
- 3. Patch cords shall have latch guards to protect against snagging.
- 4. Patch cords shall have color-coded boots for circuit identification.

B. FIBER

- 1. Approved Manufacturers:
 - a. Commscope Systimax
- 2. Patch Cords: Factory-made, dual-fiber cables in 1-meter lengths.

2.7 PATCH PANELS AND CONNECTING BLOCKS

A. Copper Panels And Connecting Blocks

- 1. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
 - a. Approved Manufacturers:
 - 1) Commscope Systimax
 - b. Features:
 - 1) Universal T568A and T568B wiring labels.
 - 2) Labeling areas adjacent to conductors.
 - 3) Replaceable connectors.
 - 4) Ports: 24 or 48.
 - 5) Rack units: 1 or 2.
 - c. Construction: 16-gauge steel and mountable on 19-inch (483 mm) equipment racks.
 - d. Number of Jacks per Field: One for each four-pair conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria.

2. Connecting Blocks:
 - a. 110-style IDC for Category 6.
 - b. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.
3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - a. Number of Terminals per Field: One for each conductor in assigned cables.

B. Fiber Panels

1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
2. Approved Manufacturers:
 - a. Commscope Systimax
3. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

2.8 WORKSTATIONS

A. Faceplate:

1. One, Two, or Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
2. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords. Jacks to be blue in color.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.
 1. Install plenum cable in environmental air spaces, including plenum ceilings.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

A. Comply with NECA 1 and NECA/BICSI 568.

B. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Do not untwist twisted pair cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.
5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
6. Consolidation points may be used only for making a direct connection to equipment outlets:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for twisted-pair cables at least 49 feet (15 m) from communications equipment room.
7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
8. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8-inches above ceilings by cable supports not more than 60-inches apart.
 3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
 4. Coil cable 10-foot long not less than 12-inches in diameter above each feed point.
- D. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
 2. Install cabling after the flooring system has been installed in raised floor areas.
 3. Coil cable 10-foot long not less than 12-inches in diameter below each feed point.
- E. Group connecting hardware for cables into separate logical fields.
- F. Separation from EMI Sources:
1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inch.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inch.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inch.
 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2 1/2 inch.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inch.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inch.
 4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inch.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inch.
 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inch.
 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inch.

3.3 INSTALLATION OF OPTICAL FIBER BACKBONE CABLES

- A. Comply with NECA 1, NECA 301, and NECA/BICSI 568.
- B. General Requirements for Optical Fiber Cabling Installation:
 - 1. Comply with TIA-568-C.1 and TIA-568-C.3.
 - 2. Comply with BICSI ITSIMM, Ch. 6, "Cable Termination Practices."
 - 3. Terminate all cables; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 - 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30-inches and not more than 6-inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 6. Bundle, lace, and train cable to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
 - 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 8. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 - 9. In the communications equipment room, provide a 10-foot-long service loop on each end of cable.
 - 10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
 - 11. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- C. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
 - 3. Coil cable 10-foot long not less than 12-inches in diameter and the minimum fiber cable bend radius specified by the manufacturer above each feed point.
- D. Installation of Cable Routed Exposed under Raised Floors:
 - 1. Install plenum-rated cable only.
 - 2. Install cabling after the flooring system has been installed in raised floor areas.
 - 3. Coil cable 15-foot long not less than 12-inches in diameter and the minimum fiber cable bend radius specified by the manufacturer below each feed point.
- E. Group connecting hardware for cables into separate logical fields.

3.4 CABLE INSTALLATION IN TRAY

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every 18-inches.
- D. Fasten and support cables that pass from one cable tray to another or drop from cable trays to equipment enclosures. Fasten cables to the cable tray at the point of exit and support cables independent of the enclosure. The cable length between cable trays or between cable tray and enclosure shall be no more than 72-inches.
- E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72-inches otherwise.
- F. In existing construction, remove inactive or dead cables from cable trays.
- G. Protect installed cable trays and cables.
 - 1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.

3.5 FIELD QUALITY CONTROL AND TESTING

- A. Copper
 - 1. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
 - 2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 - 3. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
 - 4. Perform tests and inspections with the assistance of a factory-authorized service representative.
 - 5. Tests and Inspections:
 - a. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - c. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

- d. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
6. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.
7. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
8. End-to-end cabling will be considered defective if it does not pass tests and inspections.
 - a. Prepare test and inspection reports.

B. Fiber

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
3. Perform tests and inspections with the assistance of a factory-authorized service representative.
4. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.
5. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Tests and Inspections:
 - a. Visually inspect optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - c. Optical Fiber Cable Tests:
 - 1) Test instruments shall meet or exceed applicable requirements in TIA-568-C.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 2) Link End-to-End Attenuation Tests:
 - a) Horizontal and multimode backbone link measurements: Test at 850 and 1300nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
 - b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than those calculated according to equation in TIA-568-C.1.

8. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
9. Remove and replace cabling where test results indicate that it does not comply with specified requirements.
10. End-to-end cabling will be considered defective if it does not pass tests and inspections.
11. Prepare test and inspection reports.

END OF SECTION 271000

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SECTION 271100 - COMMUNICATIONS SPACES

PART 1 - GENERAL

1.1 SUMMARY

- A. The purpose of this section is to provide guidance on the products and installation practices to be used while installing the communications spaces, including racks, cabinets, ladder tray, and other metals and accessories.
- B. Section Includes:
 - 1. 19-inch equipment racks.
 - 2. Backboards.
 - 3. Boxes, Enclosures, and Cabinets.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Requirements:
 - 1. Section 270526 "Grounding and Bonding for Telecommunications Equipment" for TMGBs and TGBs.

1.3 SUBMITTALS

A. ACTION SUBMITTALS

- 1. Product Data: For each type of product.
 - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 - b. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.
- 2. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.
 - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - b. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.

- c. Grounding: Indicate location of TGB and its mounting detail showing standoff insulators and wall-mounting brackets.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. UL listed.
- B. RoHS compliant.
- C. Compliant with requirements of the Payment Card Industry Data Security Standard.

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96-inches.
- B. Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."
- C. Plywood shall be AC Grade or better, void-free.
- D. All Plywood surfaces shall be painted with 2 coats of fire retardant paint.
- E. Backboard Paint: White

2.3 19-INCH EQUIPMENT RACKS

- A. Description: Two and Four-post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECA-310, 19-inch (482.6-mm) equipment mounting with an opening of 17.72-inches (450-mm) between rails.
- B. Approved Manufacturers:
 - 1. Hubbell Premise
- C. General Requirements:
 - 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Material: Extruded aluminum.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 - 4. Color: Black.
- D. Floor-Mounted Racks:
 - 1. Overall Height: 84 inch.

2. Two-Post Load Rating: 200 lb (91 kg).
3. Four-Post Load Rating: 1000 lb (454 kg).
4. Number of Rack Units per Rack: 48.
 - a. Numbering: Every rack units, on interior of rack.
5. Threads: 10-32.
6. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
7. Base shall have a minimum of four mounting holes for permanent attachment to floor.
8. Top shall have provisions for attaching to cable tray or ceiling.
9. Self-leveling.

E. Cable Management:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Contact telecommunications service provider and arrange for disconnection / reconnection after servicing of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
- B. The fiber entrance must be pulled back to install a more protective metal conduit. Contractor is responsible for ensuring entrance fiber is reinstalled correctly and is functional.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout of communications equipment spaces.
- C. Comply with BICSI ITSIMM for installation of communications equipment spaces.
- D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- E. Coordinate layout and installation of communications equipment in racks and room. Coordinate service entrance configuration with service provider.

1. Meet jointly with system providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
 2. Record agreements reached in meetings and distribute them to other participants.
 3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment spaces to accommodate and optimize configuration and space requirements of telecommunications equipment.
 4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.
- F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
- G. Plywood:
1. All walls must be covered with $\frac{3}{4}$ " Grade A-C plywood, sanded smooth and painted with fire-resistant paint (not fire retardant plywood unless required by local fire codes).
 2. The plywood should be mounted vertically starting at 6-inches AFF.
 3. Securely fasten plywood to wall framing members. Use flush hardware and supports to mount plywood. Ensure that the strength and placement of the hardware are sufficient to handle the total anticipated load (static and dynamic) and mounting of equipment.
 4. Install from 6 inches (150 mm) to 8 feet, 6 inches (2588 mm) above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
 5. Paint all sides of backboard with two coats of paint.
 6. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.
- H. Conduit Chase Pipes:
1. Refer to the "Pathways for Communications" section.

END OF SECTION

SECTION 272000 - DATA COMMUNICATIONS NETWORK EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes the minimum requirements for equipment located in telecommunications rooms (TRs), electronics closets, and common spaces. All equipment and layout must be verified by IT Department and/or Consultant before purchase and installation.

1.2 RELATED DOCUMENTS

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

1.3 ACTION SUBMITTALS

- A. Product Data: Documentation for each product type, organized in a single PDF or 3-Ring Binder, with a table of contents and specific part numbers clearly indicated.
- B. Shop Drawings: Provide communications rooms rack layouts for network devices to be reviewed by the Engineer, unless rack diagrams are provided as part of the contract drawings and no deviation from the design is intended.

PART 2 - PRODUCTS

2.1 DATA COMMUNICATIONS NETWORK EQUIPMENT

- A. Switches and Hubs

- 1. TYPE 1 - Switch

- a. Description: 48 Port POE Network Switch
 - b. Approved Manufacturer:
 - 1) HPE ARUBA 2930M SERIES POE+
 - c. SFP Ports: Minimum (2) SFP 100/1000 Mbps ports
 - d. Copper Ports: (44) RJ-45 auto-negotiating 10/100/1000 PoE+ ports
 - e. POE Power Budget: 400 Watts
 - f. Mounting: 19" Rack Mount w/ Brackets
 - g. Routing/Switching Capacity: 176 Gbps

- B. Wireless Access Points (WAP)

1. TYPE 1 – Interior Ceiling Mounted Wireless Access Point

- a. Description: Wireless Network Access Point
- b. Approved Manufacturer:
 - 1) HPE ARUBA INSTANT AP-515
- c. Mounting: Ceiling Mount
- d. Frequency Band: 2.40 GHz / 5 GHz

2.2 DATA COMMUNICATIONS HARDWARE

A. Uninterruptible Power Supply (UPS)

- 1. Description: Smart UPS with Extended Run and NIC
- 2. Approved Manufacturer:
 - a. APC; Smart-UPS 2200VA (SRT2200RMXLA)
- 3. Mounting: Rack Mounted 2U
- 4. Typology: On-Line
- 5. Waveform Type: Sine Wave
- 6. Runtime: Minimum 0.5 Hours runtime at maximum power consumption for all rack mounted devices, including devices on shelving in-rack.
- 7. Input: 120V; NEMA L5-20P
- 8. Output: 120V; Minimum of six NEMA 5-15R or NEMA 5-20R.
- 9. Features: Switchable outlets, capability to connect external battery packs
- 10. Interfaces:
 - a. Integrated Network Interface Card (NIC)
 - b. External Temperature Sensor.
- 11. Warranty: 3-Year

B. External Battery Packs

- 1. Description: Smart UPS 120V External Battery Pack
- 2. Approved Manufacturer:
 - a. APC, Smart-UPS On-Line 72V SRT (SRT72RMBP)
- 3. Mounting: Rack Mounted
- 4. Capacity: As required to meet runtime requirements and as indicated in contract documents.
- 5. Output: 120V
- 6. Ensure battery packs are compatible with planned uninterruptable power supply (UPS).
- 7. Batteries should be hot-swappable.

C. Power Distribution Units (PDU)

1. Description: Horizontal 20A PDU
 - a. Approved Manufacturer
 - 1) Vertiv Geist P/N: NSVLN080-102S20
 - 2) APC P/N: AP9563
 - b. Power Outputs: Minimum (8) 5-20R
 - c. Power Input: (1) 5-20P
 - d. Power Configuration: 20A, 120V, 1.9kW
 - e. Power Switch: None
 - f. Overcurrent Protection: 20A Thermal Breaker
 - g. Cord Length: 10 ft.
2. Description: Vertical 20A PDU
 - a. Approved Manufacturer
 - 1) Vertiv Geist P/N: NSVCN140-102S20
 - 2) APC P/N: AP7530
 - b. Power Outputs: Minimum (14) 5-20R
 - c. Power Input: (1) 5-20P
 - d. Power Configuration: 20A, 120V, 1.9kW
 - e. Power Switch: None
 - f. Overcurrent Protection: 20A Thermal Breaker
 - g. Cord Length: 10 ft.

PART 3 - EXECUTION

3.1 INSTALLATION OF NETWORK EQUIPMENT

- A. When rack diagrams, showing equipment mounting in the network racks, are provided as part of the construction drawings, the installer shall follow the designed layout and communicate any concerns prior to purchasing materials.
- B. When rack diagrams are not provided, shop drawings shall be provided by the installer for review by the engineer prior to ordering any materials.
- C. When rack mounting equipment use the provided hardware only. If the proper hardware isn't provided and it is available from the manufacturer, it is the installer's responsibility to purchase the correct hardware for the application. Do not attempt to improvise a solution without first consulting with the engineer or Owner's Representative.
- D. When equipment allows for multiple mounting positions, choose the position that allows the equipment faces of all devices in the rack to be as even (flush) as possible.

- E. Provide a minimum 2RU Horizontal Manager between any two switches. When stacked, provide management above the topmost switch and below the bottom most switch.
- F. Label switches, servers, routers, firewalls, PDUs, and UPSs as required, refer to Section 270553 – Identification for Communications Systems.
- G. Unless the construction documents indicate otherwise, uninterruptable power supplies (UPS) should be mounted at the bottom of the rack or cabinet. When mounting at the very bottom of the rack, install a 2RU blank fill panel above the main unit and between the unit and all batteries. When using external batteries, install the batteries below the main unit.
- H. When connecting devices for power and multiple UPSs are present, monitor the loads and divide the load as evenly as possible between all units.
- I. Provide one temperature sensor per communications rack housing a UPS and connect the UPS to the network. UPS manufacturer recommended sensors only.
- J. Provide minimum required SFP Fiber modules matching the fiber infrastructure type of the building to ensure all switches in stack of 2 or more switches can be connected and expanded unless the owner requests otherwise.
- K. Secure all rack mounted hardware with a minimum of 4 screws or cage nuts per 1RU device not using a rail kit. Replace all screws that were stripped during installation.

3.2 QUALITY CONTROL

- A. The installer shall visually inspect all packaged materials, document any damage, and notify the Owner's Representative prior to unpacking.
- B. If damage is found when unpacking materials, notify the Owner's Representative immediately.
- C. Retain all manuals, spare parts, and non-Packaging materials; package neatly and leave in the telecommunications room for the Owner.
- D. Dispose properly of all packing materials after successfully installing all equipment, while being certain not discard any of the items listed above, such as owner manuals.

3.3 REPORTING

- A. When unpacking equipment record all damage noticed and include date, delivery method, device model and manufacturer, serial number, and the name of person who discovered the damage.
- B. When equipment is damaged, take photos to document the condition of the packing and the device itself.

- C. Provide a report to the owner listing all equipment installed by the contractor in the communications spaces, as well as wireless access points, and include the following information:
1. Description of the device.
 2. Manufacturer, model, and part number.
 3. Serial number.
 4. The MAC address when available.
 5. The name that was used when the device was labeled.
 6. For wireless access points, the cable ID it was connected to in the field.
 7. The name(s) of the personnel who completed the report.

3.4 STARTUP SERVICE

- A. Perform startup service.
1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
 2. Complete installation and startup checks according to manufacturer's written instructions.

3.5 WARRANTY

- A. Contractor to ensure manufacturer's warranty is set up so that Owner is first and only Owner of equipment so that Owner can register warranty claims on their own in the future.
- B. Installer to provide any labor for hardware issues. Software, configuration or programming issues are excluded and not covered.

END OF SECTION 272000

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SECTION 274100 – AUDIOVISUAL SYSTEMS

PART 1 - GENERAL

1.1 DESCRIPTION

- A. Contract Documents are meant to convey system intent but do not guarantee all components are noted as they will be finally installed. Work under this section of the specifications includes all labor, equipment, and installation as required to provide a complete technical system in compliance with all requirements of these contract documents.

1.2 EXAMINATION OF SITE

- A. By the act of submitting a bid, the Technical System Contractor will be deemed to have made reasonable allowances for site examinations, site conditions, and included all costs in their proposal. Failure to verify these conditions will not be considered a basis for the granting of additional compensation.

1.3 MATERIAL AND WORKMANSHIP

- A. All equipment shall be new and in proper operating condition. All workmanship shall be of the finest quality by experienced installation technicians.
- B. The Technical System Contractor shall contact the Owner/Architect, in writing, regarding the selection of colors for all equipment such as loudspeaker grilles, exposed loudspeaker boxes, wall plates, millwork, laminate, and other items specific to the project.
- C. Equipment designated as either "B-Stock", "Used", or "Refurbished" will not be accepted without written approval. The Technical System Contractor shall provide full warranty for all equipment as would have been provided for new equipment unless provided with specific exemption.

1.4 ORDINANCE AND CODES

- A. The Technical System Contractor shall comply with all applicable national and local codes, ordinances, and obtain all required permits. The Technical System Contractor shall be held responsible for any violations of the law within the scope of their work.

1.5 CONTRACTOR QUALIFICATIONS

- A. Work in this section shall be performed by a Technical System Contractor who:
 - 1. Is licensed to perform work of this type in the project jurisdiction

2. Has a service center within 150 miles of project site
3. Personnel assigned to this project must have the following certifications and experience
 - a. Project Management Staff

- 1) AVIXA CTS-I

- B. The Technical System Contractor shall include, with their bid, a list of credentialed staff who will be actively involved in this project including specific tasks each will perform. Include all continuing education for each individual.
- C. The Owner may request a prospective Technical System Contractor to provide additional information as desired for review by the Owner, Architect, and AV Consultant to make a determination of the Technical System Contractor's acceptability.
- D. Other contractors bidding this work who cannot meet the above qualifications must employ the services of a qualified Technical System Contractor who meets the above qualifications. This Technical System Contractor shall supervise the installation and perform all wiring connections.

1.6 SUBSTITUTIONS

- A. Information regarding substitution of equipment/materials shall be presented in writing to the Owner, and AV Consultant for review. This written request shall contain copies of complete manufacturer's literature regarding the proposed substitute item(s), specifications, and front/rear views (if applicable).
- B. The Technical System Contractor shall be required to replace such installed substitute equipment/materials if an unforeseen defect appears, or if operational characteristics do not fulfill the design intent of the technical system.

1.7 SUBMITTALS

- A. Submittals shall comply with the overall project schedule. Failure to make timely, complete submittals will be considered a lack of substantial progress for the work in this section.
- B. All submittals are expected to be transmitted digitally. Technical Systems Contractor must provide dependable system for transmitting data and verifying its receipt.
- C. For the first submittal, the Technical System Contractor shall provide the following at least 2 weeks prior to ordering equipment:
 1. A complete list of all equipment and materials intended for the project. The material and equipment lists shall be submitted and reviewed before any equipment and material is purchased. All material and equipment lists shall include quantities separated by room and system. Quantities will not be specifically reviewed by AV Consultant and are provided for reference only.
 2. Cutsheets for all equipment with any optional elements highlighted.

3. Substitute equipment/materials shall be so noted as a "Proposed Substitute," along with a footnote briefly stating the reason for the proposed substitution.
 4. All information in this first submittal shall be bound as one complete PDF package.
- D. For subsequent submittals, at least 2 weeks prior to installation of each respective portion of work, the Technical System Contractor shall submit the following:
1. Shop drawings including floor plans, signal flows, rack layouts, and elevations.

1.8 PROTECTION OF WORK

- A. The Technical System Contractor shall protect all work, materials and equipment from damage due to any cause. They shall provide for the safety and new condition of the equipment and materials until final acceptance by the Owner. The Technical System Contractor will replace all damaged or defective materials and/or equipment as directed by the Architect or AV Consultant.
- B. Equipment racks and other exposed equipment shall be kept covered and protected from airborne contaminants. The Technical System Contractor shall clean all debris from the equipment room(s) and control console area, and shall clean all equipment and the interior rack floor, prior to system commissioning activities.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Unless otherwise designated, the Technical System Contractor shall provide all of one type of equipment from one manufacturer; for example, microphones of one type to be provided by one manufacturer; video projectors of one type by one manufacturer, all loudspeakers of one type by one manufacturer.
- B. Equipment and wiring shown on the drawings represents the basis of design. The Technical System Contractor shall ensure similar or better performance is achieved by the use of equipment other than that shown. Note, any deviation from the basis of design required the procedure outlined above under "Substitutions".

2.2 SYSTEMS DESCRIPTIONS AND CONTROL FUNCTIONALITY

- A. Hybrid Classroom
 1. Classroom supporting video conferencing, presentation, and collaboration.
 2. Required Functionality
 - a. A wall mounted interactive display provided at the front of the room will show content from PC-based conferencing system and user devices.

- b. Camera and microphone system will bridge back to PC-based conferencing system.
 - c. Overhead speakers will provide audio reinforcement,
- 3. Control Requirements
 - a. Camera shall be auto-tracking
 - b. Display shall power off upon no-signal or at end of day (10p unless otherwise specified by owner)

B. Typical Classroom or Lab

- 1. Classroom or lab supporting presentation.
- 2. Required Functionality
 - a. A wall mounted interactive display provided at the front of the room will show content from user devices.
 - b. Overhead speakers will provide audio reinforcement
- 3. Control Requirements
 - a. Camera shall be auto-tracking
 - b. Display shall power off upon no-signal or at end of day (10p unless otherwise specified by owner)

2.3 LOUDSPEAKERS

A. Ceiling Loudspeakers

- 1. Approved Manufacturers:
 - a. JBL
 - b. Extron
 - c. Atlas
 - d. Extron
 - e. Or Approved Alternate
- 2. Basis of Design Model: Refer to signal flow diagrams
- 3. Characteristics
 - a. Power Handling: 20 watts
 - b. Impedance 8-Ohm, 70v/100v (2.5, 5, 10 watts)
 - c. Coverage: 100 degrees conical
 - d. Mounting: In 2' ceiling grid
 - e. Finish Color: White

2.4 Amplifiers

A. Small Form Factor Amplifiers

1. Approved Manufacturers:
 - a. SOUNDTUBE
 - b. ATLONA
 - c. CRESTRON
 - d. EXTRON
 - e. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Channels: 2
 - b. Power/Channel @ 8 Ohm: 50 watts
 - c. Inputs: 2
 - d. Size: 6"W x 6"L x 2" H maximum

2.5 MICROPHONES

A. Wireless Microphone Systems

1. Approved Manufacturers:
 - a. SHURE
 - b. SENNHEISER
 - c. AUDIX
 - d. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Lavalier Microphone Transmitter

2.6 DIGITAL SIGNAL PROCESSING

A. Digital Signal Processor With Dante

1. Approved Manufacturers:
 - a. SHURE
 - b. EXTRON
 - c. SYMETRIX
 - d. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams

3. Characteristics
 - a. Analog I/O: 2 inputs, 2 outputs minimum
 - b. Dante I/O: 8 inputs, 8 outputs minimum
 - c. USB Interface

2.7 CONTROL SYSTEMS

A. Control Processor

1. Approved Manufacturers:
 - a. ATLONA
 - b. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics:
 - a. Ethernet, RS-232, and RELAY control

B. Button Control Panel

1. Approved Manufacturers:
 - a. ATLONA
 - b. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics:
 - a. Power: POE or POE+
 - b. Provide customized button labels

2.8 CONFERENCING SYSTEMS

A. Wireless Conferencing Solution

1. Approved Manufacturers:
 - a. BARCO
 - b. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Wireless audio/video conferencing via client application
 - b. Support for Mac, Windows, iOS, and Android casting

2.9 DISPLAYS

A. Commercial Displays

1. Approved Manufacturers:
 - a. SAMSUNG
 - b. LG
 - c. NEC
 - d. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Brightness: 300 nit minimum
 - b. Resolution: UHD (3840 x 2160)
 - c. Inputs: (2) HDMI, LAN, RS-232
 - d. Rating: Commercial, 16 hours a day, 7 days a week operation
4. Accessories
 - a. Mount: Micro-adjustable tilt display mount

B. Interactive Displays

1. Approved Manufacturers:
 - a. PROMETHEAN
 - b. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Brightness: 300 nit minimum
 - b. Resolution: UHD (3840 x 2160)
 - c. Inputs: (2) HDMI, USB, LAN, RS-232
 - d. Touch: Pen/Touch, 20 points
4. Accessories
 - a. Mount: display mount

2.10 PROJECTORS

- A. Projector specifications are based on project conditions during the design phase. Site conditions may differ from the design documents. The Technical System Contractor shall be responsible for field verifying the screen size/location, projector mounting location, throw distance, and selection of the appropriate lens. Incorrect selection of the projector lens will not be an

acceptable request for a change order. Digital manipulation of the image size is not an acceptable alternative to incorrect lens selection.

B. LASER PROJECTOR

1. Approved Manufacturers:
 - a. SONY
 - b. PANASONIC
 - c. EPSON
 - d. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Brightness: Minimum 6500 Lumens
 - b. Resolution: WUXGA
 - c. Inputs: HDMI, HDBaseT, LAN
4. Accessories
 - a. Lens: Provide lens appropriate for screen size and throw distance. Verify all dimensions prior to lens procurement.

2.11 VIDEO DISTRIBUTION

A. Video Switcher/Control Processor

1. Approved Manufacturers:
 - a. ATLONA
 - b. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics
 - a. Integrated Control Processor
 - b. HDMI Inputs
 - c. Video over Twisted Pair: (1) Input, (1) Output

B. Video Switcher Over Twisted Pair

1. Approved Manufacturers:
 - a. ATLONA
 - b. Or Approved Alternate
2. Basis of Design Model: Refer to signal flow diagrams
3. Characteristics

- a. HDMI Inputs/Outputs

2.12 DIGITAL SIGNAGE

A. Digital Signage Player

- 1. Approved Manufacturers:
 - a. SCREENCLOUD
 - b. Or Approved Alternate
- 2. Basis of Design Model: Refer to signal flow diagrams
- 3. Characteristics
 - a. HDMI Output
 - b. Network Control and Management
 - c. Scheduled Content
 - d. Compatible with existing campus standard

2.13 CAMERAS

A. PTZ Camera

- 1. Approved Manufacturers:
 - a. AVER
 - b. VADDIO
 - c. Or Approved Alternate
- 2. Basis of Design Model: Refer to signal flow diagrams
- 3. Characteristics
 - a. Pan, Tilt, Zoom functionality
 - b. Resolution: 1080p
 - c. Output: Network, HDMI, USB
 - d. Auto-tracking
 - e. Power: POE/POE+

2.14 CABLING

A. Network Cabling

- 1. Fiber Optic
 - a. Refer to section 271000 for requirements
- 2. Copper

- a. Refer to section 271000 for requirements
- B. Video Wiring
 - 1. Video Over Twisted Pair
 - a. Cable Specification: Category 6 STP Plenum
 - b. Provide shielded connections at all endpoints
 - c. Provide plenum jacketed cable in plenum spaces.
 - 2. HDMI/DisplayPort
 - a. Provide full compliance with latest released standards and versions.
 - b. Provide plenum jacketed cable in plenum spaces.
- C. Audio Wiring
 - 1. Microphone/Line Level
 - a. Provide minimum 22-gauge, 2 conductor wiring with foil shield and drain wire
 - b. Provide plenum jacketed cable in plenum spaces
 - 2. Constant Voltage Speaker
 - a. Provide minimum 16-gauge, 2 conductor wiring. Calculate loss for entire cabling path to not exceed .5 db cable loss.
 - b. Provide plenum jacketed cable in plenum spaces
 - 3. Low Impedance Speaker
 - a. Provide minimum 12-gauge 2 conductor wiring
 - b. Provide plenum jacketed cable in plenum spaces
 - 4. Antenna Cabling
 - a. Provide 50 ohm RG8/U for all distances up to 100'.
 - b. Provide LMR400 or equivalent for longer distances.
 - c. Provide all amplifications, distribution, and cabling for a fully functional system.
 - d. Provide plenum jacketed cable in plenum spaces.
- D. Control Wiring
 - 1. Provide minimum 22-gauge 4 conductor wiring with foil shield and drain wire for all serial, relay, GPIO, IR or similar communication
 - 2. Where manufacturer requirement exceeds specification gauge or conductor count, match manufacturer requirement.
 - 3. Solid core wire shall not be used for control cabling
 - 4. Provide plenum jacketed cable in plenum spaces

2.15 AC POWER

- A. The Technical System Contractor shall furnish a multi-receptacle power strip for each AC circuit within the equipment and lectern rack(s). Furnish a minimum of 2 spare receptacles (beyond that required for connected equipment, rack fan, etc.) within each equipment rack. Each equipment rack shall contain a minimum of 2 un-switched AC power receptacles.
- B. All equipment shall be connected so that maximum rated performance can be obtained without exceeding the AC circuit capability.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate with the project General/Electrical Contractor for the required location of junction boxes, outlets, and conduit.
- B. Carefully inspect areas where equipment will be installed. Notify the AV Consultant of any conditions that would adversely affect the installation and subsequent operation of the system.

3.2 WIRING METHODS

- A. Wiring Method: Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters where unenclosed wiring method may be used. Conceal pathway and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for pathways and boxes specified in Section 270528 "Pathways for Communications Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with appropriate strain relief, minimal excess, and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF CABLES

- A. General Cable Installation Requirements:
 - 1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 - 2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.

3. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

B. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches above ceiling by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

C. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate pathways or, where exposed or in same enclosure, separate conductors at least 12 inches apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other communication equipment conductors as recommended by equipment manufacturer.

1. Control and video circuits can be routed with line-level circuits if separate conduit is not furnished for these circuits.

3.4 INSTALLATION AND COORDINATION WITH OTHER TRADES

- A. The Technical System Contractor shall be responsible for the safe and proper mounting and suspension of equipment within this section. The Technical System Contractor shall employ the services of a qualified structural engineer to review all overhead mounting, suspension, and rigging details of the technical system equipment as necessary. All mounting and rigging schemes indicated on the construction drawings are shown for concept only.
- B. Coordinate layout and installation of system components and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- C. Ensure all wall-mounted outlets and backboxes for AV use are flush-mounted. If installed by another trade, note any non-compliant conditions to the general contractor for correction.
- D. Ensure all floor-mounted outlets and backboxes for AV use are concealed within the floor and cable nozzles are installed through outlet covers. All outlet covers must be secured in place and flooring/carpet tight to box cover. If installed by another trade, note any non-compliant conditions to the general contractor for correction.

- E. Coordinate all holes, penetrations, or modifications to furniture with furniture vendor and architect prior to installation. Appropriate measures should be taken to avoid damage to finished surfaces when cutting.

3.5 PHYSICAL INSTALLATION

- A. Equipment racks and other exposed equipment shall be kept covered and protected from airborne contaminants during construction and installation. The Technical System Contractor shall clean all equipment racks and the interior rack floor, prior to system commissioning activities.
- B. Equipment Cabinets and Racks:
 - 1. Group items of same function together, either vertically or side by side and arrange controls symmetrically.
 - 2. Ensure equipment is mounted so that ventilation is maintained. Do not block air exhaust or intake for any rack mounted equipment. Provide blank and/or vent panels as necessary to accommodate designed air flow and ventilation.
 - 3. All equipment racks should be designed to allow proper weight distribution. Where possible, heavy equipment should be mounted in lower sections of the rack to minimize tip hazard.
 - 4. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
 - 5. All devices should be securely mounted within racks. Provide rack shelves for owner furnished PCs and equipment as noted on drawings. Small devices without dedicated rack mount accessories should be mounted on shelves or mounting plates.
- C. Furnish all equipment with factory finish where possible using the standard available factory color(s) as selected by the Architect or Owner. The Technical System Contractor shall retain responsibility for notifying the Architect regarding color options of relevant technical system and AV equipment prior to ordering equipment from each manufacturer.
- D. Equipment installed within NFPA fire-rated ceiling structures should be coordinated with Authority Having Jurisdiction (AHJ) to ensure fire-rating of ceiling structure is maintained. Where required, provide a secondary fire-rated enclosure or surround for ceiling mounted devices that are not inherently fire-rated.
- E. Equipment mounted overhead must have secure attachment to structure independent of any architectural ceiling grid. Devices and cabling should not be directly supported by ceiling grids, tiles, or other architectural ceiling systems other than those specifically rated for supporting equipment loads.

3.6 CABLE MANAGEMENT AND TERMINATION

- A. Install all rack-mounted equipment without IEC removable power cords so that the power cords are dressed using removable fasteners such as velcro and there are no obstructions to the item being pulled out from the front of the rack.

- B. When dressing cables within the rack, do not tighten tie wraps so that the cable is deformed. Contractor shall replace any cabling damaged by incorrect installation.
- C. Use Velcro tie wraps for all laced or bound cables. Do not use zip ties for cables.
- D. Dress cables so that terminations are free from stress due to gravity acting on the cabling. Use cable supports as required depending on the size and stiffness of the cable.
- E. Do not exceed the maximum cable bend radius as specified by the cable manufacturer.
- F. Terminate cables with sufficient service loop to allow for at least one re-termination without having to open a cable bundle or pathway.
- G. All audio circuits shall be separated according to function; e.g. microphone circuits shall be separated from line-level circuits which are separated from video circuits which are separated from loudspeaker circuits. Where audio and video circuits are installed in conduit or other raceway, separate conduits are required for the various circuit functions.
- H. Circuits shall not be spliced except as shown on approved shop drawings.
- I. All audio circuits terminating to screw-type connectors shall be installed with consistent stripping of outer jacket and any exposed shield or drain wires covered by heat shrink. Wire exposed for termination should be completely within the screw terminal connection
- J. Install equipment so that it can be pulled out for repair or replacement without hindrance. If there are obstructions prohibiting the disconnection of terminations on the backside of the technical equipment, there must be sufficient cabling to permit the equipment to be pulled from the front allowing for easy disconnection.
- K. If equipment is removed or replaced for service, ensure that it is relatively easy to find the proper cable termination points when the equipment is re-installed.

3.7 LABELING

- A. All labeling of cables within equipment racks shall be clearly legible with unambiguous identifying labels. Identify all cables clearly with permanent labels wrapped about the full circumference within twelve (12) inches of each connection. Assign wire or cable designations consistently throughout a given system. Each wire or cable shall carry the same labeled designation over its entire run, regardless of intermediate terminations. Document all cable labels for record drawings.
- B. Labels shall be located near both ends of the termination and shall be visible without system disassembly (i.e. not hidden within a cable bundle). Labels shall be permanent and non-slipping. Each printed label shall have text portion fully covered by self-adhesive lamination or heat shrink.
- C. Embossed plastic tape labeling is not acceptable for labels in any location.

3.8 VIDEO EQUIPMENT INSTALLATION

- A. Coordinate structural backing required for wall mounted flat panel displays with the General Contractor prior to the installation of drywall or other wall materials.
- B. Neatly dress all cables behind a flat panel display. Cables and connections should not be visible from the viewing locations. Power cables for displays shall not be bundled with signal cables.
- C. For fixed projector installations, signal cables shall be routed within the mounted pipe. Signal cables shall not be tied to the outside of the pipe.
- D. Video wall displays shall be installed with consistent, minimal seams. Bezels shall be in contact with each adjacent display or panel and video wall surface shall be flush.

3.9 AUDIO EQUIPMENT INSTALLATION

- A. Audio systems shall be installed and tuned to comply with ANSI A102.01:2017 for a 6db coverage envelope.
- B. Systems shall be optimized for proper phase alignment and flat response across the listening area. Additional equalization for tone and preference should be conducted from an initial even response.
- C. Systems providing unattended operation (ie. no audio operator present) shall be configured to prevent feedback of presenter microphones through appropriate gain staging, microphone placement and tuning.

3.10 CONTROL SYSTEM INSTALLATION AND PROGRAMMING

- A. All control systems shall be tested prior to compilation and loading on site. Contractor will be responsible for any logical programming errors resulting in loops, data leaks, or other undesirable system performance.
- B. All user addressable portions of a control system shall be intuitive and complete in the view of the owner/AV consultant. Any portions not meeting this requirement should be adjusted by the contractor as part of system commissioning.
- C. The contractor shall work with the owner's representative to ensure all security needs are met for the system. This should include password management, network security, and active directory considerations. Security needs should be coordinated prior to on-site work and are the responsibility of the contractor to initiate coordination. Owner may require equipment samples for security testing and hardening prior to deployment.

3.11 NETWORKED AUDIOVISUAL SYSTEMS

- A. All networked audiovisual systems on isolated networks (not interfacing directly with owner networks) shall be thoroughly documented to include IP schemes, switch configuration files,

and network credentials. Information shall be provided to Owner in digital format upon project completion and as requested by Owner.

- B. The contractor is responsible for coordinating any needs for AV network requirements with Owner. The contractor should provide detailed information regarding needed IP ranges, bandwidth, POE, and traffic management when interfacing with owner networks.
- C. Contractor shall ensure all network equipment is properly secured and in line with owner security policies. Default manufacturer passwords must be changed on all networked equipment. Contractor is responsible for initiating coordination with Owner for security considerations. Owner may require equipment samples for security testing and hardening prior to deployment.

3.12 CONTRACTOR'S PRELIMINARY TESTING AND ADJUSTMENT

- A. At the completion of the installation, the Technical System Contractor shall perform the following tests on the system to ensure proper installation. The technical system shall be fully tested with all equipment on site, installed, connected, and fully operational. The Technical System Contractor shall record the results of all tests and provide this information to the AV Consultant.
- B. Preliminary tests shall include the following:
 - 1. Functional tests of all equipment. The functional tests shall include operational tests of all program source equipment (record and playback), wireless microphone system, system inputs and outputs, video switching, video distribution, operational controls, and all system electronics. Functional tests include examination for hum, buzz, hiss, ghosts, hum bars, oscillation, thumps, unintended reception of other signals such as AM or FM radio, TV, CB, ham radio, cell phones, or any other unwanted signals through the system.
 - 2. Ensure that all equipment is on the job-site and fully operational. This includes portable (not installed) items such as microphones, microphone stands, cable tester, microphone and video cables, headphones, adapters, and other loose equipment. Remove all devices from shipping or packaging containers, ready for use, and place in equipment storage cabinet.
 - 3. Any defects or malfunctions found shall be repaired or replaced by the Technical System Contractor prior to the commencement of commissioning activities by the Consultant.
 - 4. The Technical System Contractor is encouraged to contact the Consultant should problems or concerns arise during the preliminary testing activities.
- C. The Technical System Contractor shall record all wire numbers, connection numbers, and any changes to the systems accurately mapping the system installation. This information shall be used for inclusion with the system record drawings as described later in the specifications.

3.13 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate and maintain the system(s). Refer to Division 01 Demonstration and Training specifications.

- B. Provide a minimum of three (3) training sessions of a minimum four (4) hours each.

3.14 OPERATION & MAINTENANCE (O&M) MANUALS

- A. The "Equipment List" section shall include a complete list of all equipment furnished for the project in the same general order as appearing in the specifications. The list shall include the following information organized by system:
 - 1. Quantity
 - 2. Manufacturer
 - 3. Part Number
 - 4. Serial Number
- B. The Technical System Contractor shall furnish Record Drawings for the project. These shall be created from either a) the original design drawings prepared by the AV Consultant or b) created by the Technical System Contractor. The drawings shall be complete including all of the information shown on the original design drawings (including floor plans, sections, physical details, and elevations) using the Technical System Contractor's title block (including specific information indicating the system design was by the AV Consultant). Record drawings shall also include all drawings furnished during the submittal process and all other information to provide full detail of all documented aspects of the systems. Record Drawings shall be submitted to the AV Consultant for review and comment immediately upon the completion of the project.
- C. All programming and configuration files for installed equipment shall be provided uncompiled and in digital format. Any subsequent changes to programming or configuration of systems as part of the warranty period shall be provided to Owner upon completion of work.

3.15 WARRANTY

- A. The Technical System Contractor shall warrant all work executed under this contract, including all in-shop and onsite material, parts, and labor, for a period of twelve months after the date of final acceptance.
- B. The warranty services are limited to normal business hours unless additional agreements are made between the Owner and the Technical System Contractor.
- C. The Technical System Contractor shall visit the job just prior to the end of the warranty period to check all equipment for proper system operation. Any defective equipment found shall be replaced or repaired under the terms of the system warranty.
- D. The Technical System Contractor shall not be responsible for damage to the system resultant from improper use or adjustment by others, negligence, acts of nature, or other causes which are beyond the Technical System Contractor's control.

END OF SECTION 274100

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SECTION 280500 - ELECTRONIC SAFETY SECURITY GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish all material, equipment, tools, labor, and services as necessary & required to construct the fully coordinated, complete, and properly functioning Mechanical Systems as outlined in the Contract Documents.
- B. Section Includes:
 - 1. Related Documents
 - 2. Submittal Requirements
 - 3. Product Submittals
 - 4. Products
 - 5. Examination
 - 6. System Integration
 - 7. Wiring Installation
 - 8. Grounding
 - 9. Identification
 - 10. Field Quality Control
 - 11. Adjusting

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Comply with following sections when included
 - 1. 017823 "Operation and Maintenance Data"
 - 2. 260519 "Low-Voltage Electrical Power Conductors and Cables"
 - 3. 270553 "Identification for Communications Systems"
 - 4. 270526 "Grounding and Bonding for Communications Systems"

1.3 SUBMITTAL REQUIREMENTS

- A. Provide a single, complete Submittal per Specification Section.
- B. Do not combine multiple Sections in a Submittal.
- C. Clearly select each specific product to be reviewed. Unmarked pages from catalogs will not be reviewed.
- D. Highlight and clearly call to the Engineer's attention:

1. Any portion of the submittal/shop drawing that does not comply or varies from the Technology Document's requirements.
 2. Changes required for any associated building systems.
 3. Products specified but not submitted.
- E. If the Engineer has not noted an error in the Contractor's submittal, it does not relieve the Contractor from providing the correct material or equipment to fully comply with the Engineer's documents.

1.4 PRODUCT SUBMITTALS

- A. Product Data: Specific Components for Electronic Safety and Security, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.

PART 2 - PRODUCTS

2.1 PRODUCTS

- A. See appropriate Specification Sections for all product-specific information.
- B. Products shall match manufacturer(s) of existing devices installed on site. Substitutions are not allowed without express written consent from the Owner.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, backings, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
- D. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.

1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- E. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- F. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INTEGRATION

- A. Integrate systems according to the applicable Sections for each system

3.3 WIRING INSTALLATION

- A. Wiring Method: Install wiring in metal raceways according to Section 270500 "Common Work Results" Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Wiring Method: Install wiring in metal raceways except in accessible indoor ceiling spaces and interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- C. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.4 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Section 270526 "Grounding and Bonding for Communications Systems."

3.5 IDENTIFICATION

- A. Label each cable/wire pair within 1 foot of termination at device, controlling unit or head end, and any intermediate device along that overall path.

3.6 FIELD QUALITY CONTROL

- A. Testing:
 - 1. After installation, align, adjust, and balance system and perform complete testing to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 2. Provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to tests.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION 280500

SECTION 281000 - ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Contractor to expand existing access control system. It is the contractor's responsibility to schedule a site visit and coordinate with owner to determine appropriate components, licensing, compatibility and procurement process & lead times prior to bidding.
- B. Section Includes:
 - 1. Card readers, credential cards, and keypads
 - 2. Cables

1.2 RELATED DOCUMENTS

- A. See 280500 ELECTRONIC SAFETY AND SECURITY GENERAL REQUIREMENTS for general direction. Additional or divergent information related to this section is addressed below. Direction is provided for:
 - 1. Submittal Requirements
 - 2. Product Submittals
 - 3. Products
 - 4. Examination
 - 5. System Integration
 - 6. Wiring Installation
 - 7. Grounding
 - 8. Identification
 - 9. Field Quality Control
 - 10. Adjusting
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Security access system hardware shall use a single database for access-control and credential-creation functions.
- B. Follow campus standard for product selections. System must be compatible with existing Software House system.

2.2 REQUIRED PRODUCTS

- A. Wall Mount Contactless Card Reader: HID SIGNO 40NKS
- B. Mullion Mount Contactless Card Reader: HID SIGNO 20NKS
- C. SWH Panel Enclosure: PSX-WISU16-E8S
- D. SWH Boards: iStar Ultra GCM controller board, iStar Ultra ACM reader board, I8 boards, R8 boards
- E. Door Position Switches 3/4" flush mount: GRI 18012WGWH
- F. Door Position Switches Surface Mount: Seco-larm SM-4601LQ
- G. Door Position Switches Overhead Door (Floor Mount): Seco-larm SM-226LQ
- H. Batteries: 12 Ahr Minimum
- I. Circuit Supervising Resistors: GRI 6644-1 (Required on all SWH system inputs)
- J. Glass Break Detectors: Match devices in existing buildings or Owner approved alternate
- K. Motion Detectors for rooms with accessible glazing: Match devices in existing buildings or Owner approved alternate

2.3 PERFORMANCE REQUIREMENTS

- A. Approved Vendors:
 - 1. HID Global
- 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. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
 - 1. Indoors, controlled environment.
 - 2. Indoors, uncontrolled environment.
 - 3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
- D. Display: Digital visual indicator shall provide visible[and audible] status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
- E. Doors with ADA Operators: ADA paddles interfaced to access control to provide the following operation.

1. Exterior paddle disabled until a valid card read or door is on open schedule.
2. Interior paddle must first unlock door 2 seconds before operator attempts to open door.
3. Paddle located in vestibule between 2 sets of locked doors must adhere to Interior paddle requirement, but also operate both interior and exterior door with same paddle.

F. New construction or upgrades for exterior doors with card readers.

1. Single or double crashbars, must have electric retraction and built-in REX switches in both doors to provide for doors being put on an open schedule. Cannot do electrification and REX only on one half of double door entry with door operator, electrified locks and built in REX switches provided by door hardware provider. Door position switches and readers provided and installed by security contractor. Readers must be mounted on same side of door as ADA paddle, far enough back from door for wheelchair to clear door opening. Wireless paddles must provide two receivers for access control interface.

PART 3 - EXECUTION

3.1 CABLE APPLICATION

- A. Comply with TIA 569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. TIA 232-F Cabling: Install at a maximum distance of 50 ft. between terminations.
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. between terminations.
- E. Card Readers and Keypads:
 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft., and install No. 20 AWG wire if maximum distance is 500 ft..
 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of [25 ft.] between terminations. CENTRAL-STATION HARDWARE

END OF SECTION 281000

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SECTION 282000 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 SUMMARY

- A. Contractor to expand existing electronic security system. It is the contractor's responsibility to schedule a site visit and coordinate with owner to determine appropriate components, licensing, compatibility and procurement process & lead times prior to bidding.
- B. Section Includes:
 - 1. Fixed Cameras
 - 2. Pan-Tilt-Zoom Cameras

1.2 RELATED DOCUMENTS

- A. See 280500 ELECTRONIC SAFETY AND SECURITY GENERAL REQUIREMENTS for general direction. Additional or divergent information related to this section is addressed below. Direction is provided for:
 - 1. Submittal Requirements
 - 2. Product Submittals
 - 3. Products
 - 4. Examination
 - 5. System Integration
 - 6. Wiring Installation
 - 7. Grounding
 - 8. Identification
 - 9. Field Quality Control
 - 10. Adjusting
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
- B. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened

or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

2.2 MANUFACTURER

- A. Avigilon is the campus standard product, however some Panasonic may be installed as well. The system must tie into the existing campus surveillance monitoring system. Contractor is responsible for coordinating with owner regarding part numbers and procurement of appropriate hardware, cameras and licensing. Campus PD is to be coordinated with to determine which system they want for cameras (Avigilon or Panasonic).

2.3 REQUIRED PRODUCTS

- A. Fixed Cameras
 - 1. AVIGILON - As directed by Owner. Part numbers to be updated in future addendum.
- B. Pan-Tilt-Zoom Camera
 - 1. AVIGILON (ONVIF)2.0C-H4IRPTZ-DP30-WP

2.4 CAMERA POWER

- A. Power over Ethernet (PoE)
 - 1. Comply with IEEE802.3af standard

PART 3 - EXECUTION

3.1 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras level and plumb.
- B. Install cameras with 84-inch-minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
- D. Identify system components, wiring, cabling, and terminals according to Section 270553 "Identification for Communications Systems."

3.2 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

END OF SECTION 282000

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SECTION 284600 – FIRE ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Provide emergency communication fire alarm system with manual activation of fire alarm, intruder lockdown, and severe weather notifications.
- B. Emergency communication system shall part of Owner's Siemens Desigo control system.
- C. Section Includes:
 - 1. Addressable fire alarm and detection system with voice notification.
 - 2. Fire-alarm control panel (FACP).
 - 3. Manual fire-alarm pull-stations.
 - 4. System smoke detectors.
 - 5. Carbon-dioxide detectors.
 - 6. Heat detectors.
 - 7. Notification appliances.
 - 8. Fire alarm remote annunciators.
 - 9. Fire alarm addressable interface devices.
 - 10. Digital alarm communicator transmitters (DACTs).
- D. Related Requirements:
 - 1. Section 087100 "Door Hardware" for magnetic door holders that release in response to fire alarm outputs.
 - 2. Section 233300 "Air Duct Accessories" for smoke dampers and combination fire/smoke dampers.
 - 3. Section 260519 "Low-Voltage Electrical Power Conductors and Cables".
 - 4. Section 260533 "Raceways and Boxes for Electrical Systems".

1.3 DEFINITIONS

- A. AHJ: Authorities having jurisdiction.
- B. DACT: Digital alarm communicator transmitter.
- C. FAA: Fire alarm annunciator unit.

- D. FACP / FACU: Fire alarm control panel / unit.
- E. LED: Light-emitting diode.
- F. NAC: Notification appliance circuit.
- G. NICET: National Institute for Certification in Engineering Technologies.
- H. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
 - 1. Control Voltage: Listed and labeled for use in remote-control, signaling, and power-limited circuits supplied by a Class 2 or Class 3 power supply having rated output not greater than 150 V and 5 A, allowing use of alternate wiring methods complying with NFPA 70, Article 725.
 - 2. Low Voltage: Listed and labeled for use in circuits supplied by a Class 1 or other power supply having rated output not greater than 1000 V, requiring use of wiring methods complying with NFPA 70, Article 300, Part I.

1.4 ACTION SUBMITTALS

- A. Submittals shall be combined into the fewest possible submittals, as opposed to each portion being submitted separately.
- B. Approved Permit Submittal: Submittals must be approved by authorities having jurisdiction prior to submitting them to Architect/Engineer.
- C. Project Information:
 - 1. Documentation of Installer Qualifications:
 - a. Trained and certified by manufacturer in fire alarm system design.
 - b. Fire alarm certified by NICET, minimum Level III.
 - 2. Project Title Sheet with Contact Information:
 - a. Project name and address.
 - b. Contractor's name, address, and telephone number.
 - c. Installer's name, address, and telephone number.
 - d. Manufacturer's name, address, and telephone number.
 - e. Date submitted.
- D. Product Data: For each type of product, including furnished options and accessories.
 - 1. Specifically indicate complete model number for each system component/device. Information and options not included shall be crossed out
 - 2. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 3. Include rated capacities, operating characteristics, and electrical characteristics.
- E. Shop Drawings: For fire alarm system.

1. Comply with recommendations and requirements in "Documentation" section of "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, and details, including details of attachments to other Work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Details for FAA units as required by authorities having jurisdiction.
5. Detail assembly and support requirements.
6. Include voltage drop calculations for notification-appliance circuits.
7. Include battery-size calculations and identify spare capacity available.
 - a. Include power supply calculations and identify spare capacity available.
 - b. Include amplifier calculations and power loss calculations for notification appliances.
8. Include input/output operations matrix (sequence of operation per NFPA 72).
9. Include written statement from manufacturer that equipment and components have been tested as a system and comply with requirements in this Section and in NFPA 72.
10. Include performance parameters and installation details for each detector.
11. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
12. Provide control wiring diagrams for fire alarm interface to HVAC; coordinate location of duct smoke detectors and access to them.
 - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 - b. Show field wiring and equipment required for HVAC unit shutdown on alarm.
 - c. Locate detectors in accordance with manufacturer's written instructions.
13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, and single-line connection diagram.
14. Floor Plans:
 - a. Submit drawings produced and plotted via electronic means (not hand drafted) for review. See Division 01 Section, "CAD Electronic Media Transfer Agreement" for obtaining AutoCAD files from the Architect and for associated request form and fees.
 - b. 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. Show room names that indicate actual room use and actual number designations.
 - d. Show the locations of all system panels and devices, including monitor modules, control modules, and relays.
 - e. Show the designated address of each addressable device.
 - f. Show the cabling pathways between control panel(s), supervising station/annunciator panels, voice command, and shared communications equipment.

- g. Show the general routing of cabling to each fire alarm device/notification appliance.
 - h. Show typical mounting height elevations for wall-mounted devices and appliances.
 - i. Indicate the selected candela rating for each visual (strobe) device.
- F. Delegated Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by a NICET certified professional who meets the qualifications listed below under the article titled "Quality Assurance".
 - 1. Drawings showing location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of device.
 - a. Include designation of acoustically distinguishable spaces and method for testing intelligibility and audibility levels. In each room where voice notification is required indicate the value of the minimum required sound pressures to achieve code compliance.
 - 2. Design Calculations: Calculate requirements for selecting spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
 - 3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 CLOSEOUT SUBMITTALS

- A. Field quality-control reports.
- B. Record Drawings:
 - 1. Include record documents (as-built drawings) that accurately reflect the actual completed installation, actual devices, actual room names, and actual locations within each room. Revise, update, and edit all Pre-Installation Documents as defined above, including updated riser diagrams.
 - 2. Electronic files shall be shared via electronic media and recorded on two (2) flash-drives. Hardcopies shall be as indicated above for shop drawings.
- C. Operation and Maintenance Data: For fire alarm systems and components to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Comply with "Records" section of "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire alarm and Emergency Communications System Record of Completion Documents" in accordance with "Completion Documents" Article in "Documentation" section of "Fundamentals" chapter in NFPA 72.

- c. Complete wiring diagrams showing connections between devices and equipment. Each conductor must be numbered at every junction point with indication of origination and termination points.
- d. Riser diagram.
- e. Device addresses.
- f. Record copy of site-specific software.
- g. Provide "Inspection and Testing Form" in accordance with "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
- h. Manufacturer's required maintenance related to system warranty requirements.
- i. Abbreviated operating instructions for mounting at FACU and each annunciator unit.

D. Software and Firmware Operational Documentation:

- 1. Software operating and upgrade manuals.
- 2. Program Software Backup: On USB media and approved online or cloud solution.
- 3. Device address list.

1.6 QUALITY ASSURANCE

A. Installer Qualifications:

- 1. Personnel must be trained and certified by manufacturer for installation of units required for this Project.
- 2. Installation must be by personnel certified by NICET as fire alarm Level III technician.
- 3. Obtain certification by NRTL in accordance with NFPA 72.
- 4. Licensed or certified by authorities having jurisdiction.
- 5. Supplier/Service Provider: Must confirm and maintain an authorized service representative within 90 miles travel distance from the location of the installation.

B. Compliance with Local Codes and Ordinances: Comply with all applicable building codes, local ordinances, regulations, and the all the requirements of the AHJ.

C. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.

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. This contract shall include all hardware, firmware, software, programming, electric power, cabling pathways/raceways, electrical boxes, cabling, outside plant (if applicable), and all system components to be supplied and installed for a complete and functional turnkey system—

without exception. To achieve this, this contractor and subcontractors shall be responsible under this contract for determining—prior to submitting bids—any field conditions as applicable, complete requirements for new work and the delineation of all work amongst qualified installers and technicians necessary for a fully functional and professional installation

1.7 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning with Substantial Completion, provide software support for one year.
- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide two weeks' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.8 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Lamps for Strobe Units: Quantity equal to five percent (5%) of amount installed, but no fewer than one unit.
 - 2. Smoke Detectors and Heat Detectors: Quantity equal to five percent (5%) of amount of each type installed, but no fewer than one unit of each type.
 - 3. Carbon Monoxide Detectors: Quantity equal to five percent (5%) of amount of each type installed, but no fewer than one unit of each type.
 - 4. Detector Bases: Quantity equal to two percent (2%) of amount of each type installed, but no fewer than one unit of each type.
 - 5. Keys and Tools: One extra set for access to locked or tamper-proofed components.
 - 6. Audible and Visual Notification Appliances: One of each type installed.
 - 7. Fuses: Two (2) of each type installed in system. Provide in box or cabinet with compartments marked with fuse types and sizes.
- B. Include a list of extra materials—confirmed and signed by Owner's representative - in the Operation and Maintenance Manuals.

1.9 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace fire alarm system equipment and components that fail because of defects in materials or workmanship within specified warranty period.

1. Special Extended Warranty Period: Shall exceed four (4) years starting from the date of Substantial Completion.
 - a. If the manufacturer's warranty commences upon the date that materials are delivered, then the manufacturer's warranty period shall be at least five (5) years to meet the requirement stated above.
2. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the warranty period.
3. Warranty shall cover repair or replacement of such parts determined defective upon inspection, including the full cost of related materials and labor. Additionally, there shall be no expense to the Owner due to "other-than-normal" working hours.
 - a. Warranty shall not cover any labor expended or materials used to repair any equipment without manufacturer's prior written authorization.
 - b. Warranty does not cover any product or part of a product subject to accident, negligence, alteration, abuse or misuse. Warranty does not cover any accessories or parts not supplied under this contract.
4. A service contract shall be offered to the Owner proposing regular or ongoing factory-authorized service of the installed system.

PART 2 - PRODUCTS

2.1 SYSTEM MANUFACTURER

- A. Subject to compliance with all requirements, provide system components, equipment, and products by one of the following:
 1. Siemens
- B. Wire and Cable:
 1. Comtran Corp.
 2. Helix/HiTemp Cables, Inc. (Draka USA Co.).
 3. Rockbestos-Suprenant Cable Corp. (Marmon Group Co.).
 4. West Penn Wire/CDT (Cable Design Technologies).

2.2 ADDRESSABLE EMERGENCY COMMUNICATION FIRE ALARM AND DETECTION SYSTEM

- A. Description:
 1. Integrated emergency communication fire alarm, intruder lockdown, and severe weather system.
 2. System shall be part of Siemens Designo system.

3. Noncoded, addressable, true analog sensors, fully supervised, automatic sensitivity control of smoke sensors, multiplexed signal transmission and voice notification-and-strobe notification for evacuation.

B. Performance Criteria:

1. The system shall be complete and fully operational. Provide all necessary auxiliary relays, hardware, connections, and programming to achieve the functions required herein and as indicated on the Fire Alarm System Operations Matrix under PART 4 below.
2. Regulatory Requirements:
 - a. Fire alarm Components, Devices, and Accessories: Listed and labeled by a NRTL in accordance with NFPA 72 for use with selected fire alarm system and marked for intended location and application (and recognized by the AHJ).
3. General Characteristics:
 - a. Site-Specific System Operations and Functions:
 - 1) Refer to the Drawings Fire Alarm Sequence of Operations and Fire Alarm Operations Matrix under PART 4 below.
 - b. Automatic sensitivity control of certain smoke detectors.
 - c. Fire alarm signal initiation must 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) Carbon monoxide detectors.
 - 8) Combustible gas detectors.
 - 9) Automatic sprinkler system water flow.
 - d. Fire alarm signal must initiate the following actions:
 - 1) Continuously operate alarm notification appliances.
 - 2) Identify alarm and specific initiating device at FACP, connected network control panels, off-premises network control panels, and remote annunciators.
 - 3) Transmit alarm signal to remote alarm receiving station.
 - 4) Unlock electric door locks in designated egress paths.
 - 5) Release fire and smoke doors held open by magnetic door holders.
 - 6) Activate voice/alarm communication system.
 - 7) Shutdown HVAC equipment having capacities of 2000 CFM or greater.
 - 8) Close smoke dampers in air ducts of designated air-conditioning duct systems.
 - 9) Recall elevators to primary or alternate recall floors.

- 10) Activate elevator power shunt trip.
 - 11) Record events in non-volatile system memory.
- e. Supervisory signal initiation must be by one or more of the following devices and actions:
- 1) Valve supervisory switch.
 - 2) Supervision of elevator shunt-trip mechanism, where applicable.
 - 3) Independent fire-detection and -suppression systems.
 - 4) Zones or individual devices have been disabled.
 - 5) FACP has lost communication with network.
- f. System trouble signal initiation must be by one or more of the following devices and actions:
- 1) Open circuits, shorts, and grounds in designated circuits.
 - 2) Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - 3) Loss of communication with addressable sensor, input module, relay, control module, remote annunciator, or Ethernet module.
 - 4) Loss of primary power at FACP.
 - 5) Ground or single break in internal circuits of FACP.
 - 6) Abnormal ac voltage at FACP.
 - 7) Break in standby battery circuitry.
 - 8) Failure of battery charging.
 - 9) Abnormal position of switch at FACP or annunciator.
 - 10) Voice signal amplifier failure.
- g. System Supervisory Signal Actions:
- 1) Initiate notification appliances.
 - 2) Identify specific device initiating event at FACP.
 - 3) After time delay of 200 seconds, transmit trouble or supervisory signal to remote alarm receiving station.
 - 4) Transmit system status to building management system.
 - 5) Display system status on graphic annunciator.
- h. Network Communications:
- 1) Provide network communications for fire alarm system in accordance with fire alarm manufacturer's written instructions.
 - 2) Provide network communications pathway per manufacturer's written instructions and requirements in NFPA 72 and NFPA 70.
 - 3) Provide integration gateway connection to building automation system.
- i. Device Guards:
- 1) Description: Welded wire mesh of size and shape for smoke detector, notification appliance, or other device requiring protection.

- a) Factory fabricated and furnished by device manufacturer.
- b) Factory Finish: Paint of color to match protected device.

j. Document Storage Box:

- 1) Description: Enclosure to accommodate standard 8-1/2-by-11-inch manuals and loose document records. Legend sheet will be permanently attached to door for system required documentation, key contacts, and system information. Provide two key ring holders with location to mount standard business cards for key contact personnel.
- 2) Material and Finish: 18-gauge cold-rolled steel; four mounting holes.
- 3) Color: Red powder-coat epoxy finish.
- 4) Labeling: Permanently screened with 1-inch-high lettering "SYSTEM RECORD DOCUMENTS" with white indelible ink.
- 5) Security: Locked with 3/4-inch barrel lock. Provide solid 12-inch stainless steel piano hinge.

2.3 FIRE-ALARM CONTROL PANEL (FACP) OR UNIT (FACU)

A. Description: Field-programmable, microprocessor-based, modular, power-limited design with electronic modules.

B. Performance Criteria:

- 1. Regulatory Requirements: Comply with NFPA 72 and UL 864.
- 2. General Characteristics:
 - a. System software and programs must be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining information through failure of primary and secondary power supplies.
 - b. Include real-time clock for time annotation of events on event recorder.
 - c. Provide communication between FACU and remote circuit interface panels, annunciators, and displays.
 - d. FACU must be listed for connection to the central station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. System must require no manual input to initialize in the event of complete power down condition. FACU must provide minimum 500-event history log.
 - f. Addressable Initiation Device Circuits: FACU must indicate which communication zones have been silenced and must provide selective silencing of alarm notification appliance by building communication zone.
 - 1) Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: FACU must be listed for releasing service.
 - g. FAA Unit (Fire Alarm Annunciator): Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.

- 1) Annunciator and Display: LCD, 80 characters, minimum.
 - 2) Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- h. Alphanumeric Display and System Controls: Arranged for interface between human operator at FACU and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and programming and control menu.
 - 1) Annunciator and Display: LCD, three lines of 80 characters, minimum.
 - 2) Keypad: Arranged to permit entry and execution of programming, display, and to indicate control commands to be entered into system for control of smoke-detector sensitivity and other parameters.
- i. Initiating- Device, Notification-Appliance, and Signaling-Line Circuits:
 - 1) Pathway Class Designations: NFPA 72, Class B.
 - 2) Pathway Survivability: Level 0 or Level 1.
 - 3) Install no more than 125 addressable devices on each signaling-line circuit.
 - 4) Install fault circuit isolators to comply with circuit performance requirements of NFPA 72 or with manufacturer's written instructions, whichever is more conservative.
- j. Serial Interfaces:
 - 1) One dedicated RS 485 port for central-station and remote-station operation using point ID DACT.
 - 2) One RS 485 port for remote annunciators, Ethernet module, or multi-interface module.
 - 3) One USB port for PC configuration.
 - 4) One RS 232 port for PC configuration.
 - 5) One RS 232 port for voice evacuation interface.
- k. Smoke Alarm Verification:
 - 1) Initiate audible and visible indication of "alarm-verification" signal at FACU.
 - 2) Activate approved "alarm-verification" sequence at FACU and detector.
 - 3) Sound general alarm if alarm is verified.
 - 4) Cancel FACU indication and system reset if alarm is not verified.
- l. Notification-Appliance Circuit:
 - 1) Audible appliances must sound in three-pulse temporal pattern, as defined in NFPA 72.
 - 2) Where notification appliances provide signals to sleeping areas, alarm signal must be 520 Hz square wave with intensity 15 dB above average ambient sound level or 5 dB above maximum sound level, or at least 75 dB(A-weighted), whichever is greater, measured at pillow.

- 3) Visual alarm appliances must flash in synchronization where multiple appliances are in same field of view, as defined in NFPA 72.
- m. Elevator Recall: Initiate by one of the following alarm-initiating devices:
- 1) Elevator lobby detectors except lobby detector on designated floor.
 - 2) Smoke detectors in elevator machine room.
 - 3) Smoke detectors in elevator hoist-way.
- n. Elevator controller must be programmed to move cars to alternate recall floor if lobby detectors located on designated recall floors are activated.
- o. Water-flow alarm connected to sprinkler in elevator shaft and elevator machine room must shut down elevators associated with location without time delay.
- 1) Water-flow switch associated with sprinkler in elevator pit may have delay to allow elevators to move to designated floor.
- p. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls must be connected to fire alarm system.
- q. Remote Smoke-Detector Sensitivity Adjustment: Controls must select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system nonvolatile memory.
- r. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to remote alarm station.
- s. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in separate cabinet or special module that is part of FACU.
- t. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of central-control microphone. Amplifiers must comply with UL 1711.
- 1) Allow application of, and evacuation signal to, indicated number of zones and simultaneously allow voice paging to other zones selectively or in combination.
 - 2) Programmable tone and message sequence selection.
 - 3) Standard digitally recorded messages for "Evacuation" and "All Clear."
 - 4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of FACU.
- u. Status Annunciator:
- 1) Indicate status of various voice/alarm speaker zones.
 - 2) Indicate status of firefighter's microphone.

- v. Preamplifiers, amplifiers, and tone generators must automatically transfer to backup units, on primary equipment failure.
- w. Primary Power: 24 V(dc) obtained from 120 V(ac) service and power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, must be powered by 24 V(dc) source.
 - 1) Equipment power supplies shall be served from a dedicated 20A/1P circuit breaker. Each circuit breaker shall be furnished with a red handle and lock-on clip, and shall be identified with engraved label that reads, "FIRE ALARM SYSTEM POWER."
 - 2) Convenience Receptacle: For maintenance purposes (whether shown on the power plans or not) this contractor shall install a NEMA 5-20R duplex receptacle within 3 feet of the FACU, connected to a 120V 20A branch circuit.
- x. Alarm current draw of entire fire alarm system must not exceed 80 percent of power-supply module rating.
- y. Secondary Power: 24 V(dc) supply system with batteries, automatic battery charger, and automatic transfer switch.
- z. Batteries: Sealed, maintenance free.

C. System Circuits

- 1. Signaling Line Circuits: NFPA 72, Class B, Style 4.
- 2. Initiating Device Circuits (non-addressable circuits): NFPA 72, Class B, Style B.
- 3. Notification-Appliance Circuits: NFPA 72, Class B, Style Y.
- 4. Actuation of alarm notification appliances, emergency voice alarm communications, annunciation, and other system operations shall occur within 10 seconds after the activation of an initiating device.
- 5. Electrical monitoring for the integrity of wiring external to the FACU for mechanical equipment shutdown and magnetic door-holding circuits is not required, provided a break in the circuit will automatically cause doors to close and mechanical equipment to shut down (fail-safe configuration).

D. System Capacities and Constraints

- 1. Minimum Quantity of Addressable Points per SLC (Signaling Line Circuit): 198.
- 2. Minimum Quantity of Addressable Analog Sensor Inputs per SLC: 99.
- 3. Minimum Quantity of SLCs without expanding or adding *any* hardware other than SLC cards/modules that can be inserted into available slots: 8.
- 4. Voice Notification Audio Amplifiers:
 - a. Total amplifier power rating shall be determined based upon actual Watt rating for each speaker.
 - b. Provide fully redundant back-up audio amplifiers.
- 5. Contractor may elect to supply and install remote NAC extender panel(s). Coordinate exact location prior to installation. This contractor shall include all necessary electrical provisions, such as 120-volt power connections to panel(s). NAC extender panel shall comply with NFPA 72 requirements and these specifications.

E. Accessories:

1. Instructions: Computer printout or typewritten instruction card mounted behind plastic or glass cover in stainless steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe functional operation of system under normal, alarm, and trouble conditions.

2.4 MANUAL FIRE-ALARM PULL STATIONS

- A. General Requirements for Manual Fire Alarm Pull Stations: Comply with UL 38. Boxes must be finished in red with molded, raised-letter operating instructions in white color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Dual action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACP.
2. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false alarm operation.
3. Able to perform at up to 90 percent relative humidity at 90 deg F (32 deg C).
4. Material: Manual stations made of Lexan polycarbonate.
5. Lettering on pull stations shall read "FIRE".

2.5 MANUAL INTRUDER LOCKDOWN PULL STATIONS

- A. General Requirements for Manual Intruder Alarm Pull Stations: Comply with UL 38. Boxes must be finished in white with molded, raised-letter operating instructions in blue color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Dual action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACP.
2. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false alarm operation.
3. Able to perform at up to 90 percent relative humidity at 90 deg F (32 deg C).
4. Material: Manual stations made of Lexan polycarbonate.
5. Lettering on pull stations shall read "LOCKDOWN".

2.6 MANUAL SEVERE WEATHER PULL STATIONS

- A. General Requirements for Manual Severe Weather Alarm Pull Stations: Comply with UL 38. Boxes must be finished in blue with molded, raised-letter operating instructions in white color; must show visible indication of operation; and must be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Dual action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to FACP.
2. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at top to permit lifting for access to initiate alarm. Lifting cover actuates integral battery-powered audible horn intended to discourage false alarm operation.
3. Able to perform at up to 90 percent relative humidity at 90 deg F (32 deg C).
4. Material: Manual stations made of Lexan polycarbonate.
5. Lettering on pull stations shall read "TORNADO".

2.7 SYSTEM SMOKE DETECTORS

A. Photoelectric Smoke Detectors:

1. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) NFPA 72.
 - 2) UL 268.
 - b. General Characteristics
 - 1) Detectors shall be two-wire type.
 - 2) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP.
 - 3) Base Mounting: Detector and associated electronic components must be mounted in twist-lock module that connects to fixed base. Provide terminals in fixed base for connection to building wiring.
 - 4) Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 5) Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
 - 6) Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
 - 7) Operator at FACU, having designated access level, must be able to manually access the following for each detector:
 - a) Primary status.
 - b) Device type.
 - c) Present average value.
 - d) Present sensitivity selected.
 - e) Sensor range (normal, dirty, etc.).
 - 8) Detector must have functional humidity range within 10 to 90 percent relative humidity.
 - 9) Color: White.
 - 10) Remote Control: Unless otherwise indicated, detectors must be digital-addressable type, individually monitored at FACU for calibration,

sensitivity, alarm condition, and individually adjustable for sensitivity by FACP.

- 11) Multiple levels of detection sensitivity for each sensor.
- 12) Minimum Alarm Set-Point Range: 1.0 percent to 3.7 percent per ft.

2.8 DUCT SMOKE DETECTORS

A. Description: Photoelectric-type, duct-mounted smoke detector.

B. Performance Criteria:

1. Regulatory Requirements:

- a. NFPA 72.
- b. UL 268A.

2. General Characteristics:

- a. Detectors shall be two-wire type.
- b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACP.
- c. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
- d. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status. Provide combination remote status, alarm indicator, and test station device under the following conditions:
 - 1) If detector is installed above an accessible ceiling install a remote device flush in ceiling tile directly below detector. Provide white faceplate.
 - 2) If detector is exposed but not readily visible from a floor standing position install a remote device on a nearby wall. Install flush in wall if remote device is located in a finished space.
- e. Detector address must be accessible from FACU and must be able to identify detector's location within system and its sensitivity setting.
- f. Alarm Set-Point: 2.5 percent per ft.
- g. Operator at FACU, having designated access level, must be able to manually access the following for each detector:
 - 1) Primary status.
 - 2) Device type.
 - 3) Present average value.
 - 4) Present sensitivity selected.
 - 5) Sensor range (normal, dirty, etc.).
- h. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with supplied detector for smoke detection in HVAC system ducts.
- i. Each sensor must have multiple levels of detection sensitivity.

- j. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
- k. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit. Supervised control relay must be located within three (3) feet of the fan controller.

2.9 CARBON MONOXIDE DETECTORS

- A. Description: Carbon monoxide detector listed for connection to fire alarm system.
- B. Performance Criteria:
 - 1. Regulatory Requirements:
 - a. NFPA 72
 - b. NFPA 720.
 - c. UL 2075.
 - 2. General Characteristics:
 - a. Mounting: Adapter plate for outlet box mounting.
 - b. Testable by introducing test carbon monoxide into sensing cell.
 - c. Detector must provide alarm contacts and trouble contacts.
 - d. Minimum 8-year lifespan. Detector must send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
 - e. Selectable Alarm Set-Points: 70 ppm, 150 ppm, and 400 ppm.
 - f. Locate, mount, and wire in accordance with manufacturer's written instructions.
 - g. Provide means for addressable connection to fire alarm system.
 - h. Test button simulates alarm condition.

2.10 HEAT DETECTORS

- A. Combination-Type Heat Detectors:
 - 1. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) NFPA 72.
 - 2) UL 521.
 - b. General Characteristics:
 - 1) Temperature sensors must test for and communicate sensitivity range of device.
 - c. Actuated by fixed temperature of 135 deg F (57 deg C) or rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

- d. Mounting: Twist-lock base interchangeable with smoke-detector bases.
- e. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
- f. Detector must have functional humidity range of 10 to 90 percent relative humidity.
- g. Color: White.

B. Fixed-Temperature-Type Heat Detectors:

1. Performance Criteria:

a. Regulatory Requirements:

- 1) NFPA 72.
- 2) UL 521.

b. General Characteristics:

- 1) Actuated by temperature that exceeds fixed temperature of 190 deg F (88 deg C).
- 2) Mounting: Twist-lock base interchangeable with smoke-detector base.
- 3) Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to FACU.
- 4) Detector must have functional humidity range of 10 to 90 percent.
- 5) Color: White.

2.11 FIRE ALARM NOTIFICATION APPLIANCES

A. Fire Alarm Voice/Tone Speaker Notification Appliances:

- 1. Description: Notification appliances capable of outputting voice evacuation messages.
- 2. Performance Criteria:

a. Regulatory Requirements:

- 1) NFPA 72.
- 2) UL 2572 (for emergency mass notification systems).
- 3) UL 1480.

b. General Characteristics:

- 1) High-Range Units: Rated 2 to 15 W.
- 2) Low-Range Units: Rated 1 to 2 W.
- 3) Matching Transformers: Tap range matched to acoustical environment of speaker location.
- 4) Mounting: Factory finished faceplate, wall-mount or ceiling-mount as indicated on the Drawings; semi-recessed, except where identified as surface mounted on the Drawings; bidirectional, where indicated on the Drawings.

5) Colors:

- a) Wall-mounted notification devices shall be red with white lettering.
- b) Ceiling-mounted notification devices shall be white or off-white with red lettering.
- c. Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- d. Protective Guards: Provide manufacturer's wire-guard or impact resistant acrylic guard over devices exposed to a higher-than-normal risk of damage, such as in gymnasiums, locker rooms, and other areas as indicated on the Drawings.
- e. Wet or Damp Location Devices: Provide devices designed for wet and damp location applications or exterior applications wherever devices might be subjected to moisture, such as locker rooms, dishwashing rooms, outdoors, etc.

B. Fire Alarm Visible Notification Appliances:

- 1. Description: Strobe device with polycarbonate lens mounted on aluminum faceplate:
 - a. Fire Alarm Notification: Clear polycarbonate lens.
- 2. Performance Criteria:
 - a. Regulatory Requirements:
 - 1) NFPA 72.
 - 2) UL 1971.
 - b. Synchronization: All strobes within a common area must be synchronized.
 - c. General Characteristics:
 - 1) Rated Light Output:
 - a) Initial setting shall be assumed to be 110 cd.
 - b) 15/30/75/110 cd, selectable in field by contractor based upon actual area of required coverage.
 - 2) For units with guards to prevent physical damage, light output ratings must be determined with guards in place.
 - 3) Flashing must be in temporal pattern, synchronized with other units.
 - 4) Strobe Leads: Factory connected to screw terminals.
 - 5) Mounting: Factory finished faceplate, wall-mount or ceiling-mount as indicated on the Drawings; semi-recessed, except where identified as surface mounted on the Drawings.
 - 6) Colors: Match same requirements specified for speaker notification appliances above.

- d. Combination Devices: Factory-integrated audible and visible devices in single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- e. Protective Guards: Provide manufacturer's wire-guard or impact resistant acrylic guard over devices exposed to a higher-than-normal risk of damage, such as in gymnasiums, locker rooms, and other areas as indicated on the Drawings.
- f. Wet or Damp Location Devices: Provide devices designed for wet and damp location applications or exterior applications wherever devices might be subjected to moisture, such as locker rooms, dishwashing rooms, outdoors, etc.

2.12 FIRE ALARM REMOTE ANNUNCIATORS

A. Performance Criteria:

- 1. Regulatory Requirements:
 - a. NFPA 72.
- 2. General Characteristics:
 - a. Annunciator functions must match those of FACU for alarm, supervisory, and trouble indications. Manual switching functions must match those of FACU, including acknowledging, silencing, resetting, and testing.
 - 1) Mounting: Semi-recessed cabinet, NEMA 250, Type 1, except where specifically indicated otherwise on the Drawings.
 - 2) Display Type and Functional Performance: Alphanumeric display and LED indicating lights must match those of FACU. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 ADDRESSABLE INTERFACE / MONITOR MODULES

A. Performance Criteria:

- 1. Regulatory Requirements:
 - a. NFPA 72.
- 2. General Characteristics:
 - a. Include address-setting means on module.
 - b. Store internal identifying code for control panel use to identify module type.
- 3. Circuit Supervision:
 - a. Monitoring Circuit: End-of-line resistor/relay (per manufacturer) installed integral to interface device with 4-wire loop extended to all normally open contacts.

- b. Power Circuit: If 2-wire 24 VDC circuit is needed to power the interface device, provide end-of-line resistor/rely (per manufacturer) at end of circuit
- 4. Refer to the Fire Alarm Sequence of Operations and Fire Alarm Operations Matrix for functions monitored by addressable monitor modules.

2.14 FIRE ALARM ADDRESSABLE CONTROL MODULES

A. Performance Criteria:

- 1. Regulatory Requirements:
 - a. NFPA 72.
- 2. General Characteristics:
 - a. Include address-setting means on module.
 - b. Store internal identifying code for control panel use to identify module type.
 - c. Listed for controlling HVAC fan motor controllers.
 - d. Integral or Slave Relay: Capable of providing direct signal to elevator controller to initiate elevator recall, to circuit-breaker shunt trip for power shutdown, to smoke dampers, to ventilation equipment for fan shutdown, door hold-open release, and other functions as indicated on the Drawings.
 - 1) Allow control panel to switch relay contacts on command.
 - 2) Have minimum of two normally open and two normally closed contacts available for field wiring.
- 3. Provide addressable control relays as needed to achieve system functions described within this section or as indicated on the Drawings. If necessary, provide both an addressable control relay and auxiliary/slave relay(s) designed and rated to match the characteristics of the actual electrical load served.
- 4. Each addressable control relay shall be located as near as possible to the device that it controls, unless otherwise indicated. All control relays shall be mounted in or on a junction box in an accessible location.
- 5. Wherever a control relay is not visible from a floor standing position, a remote indicator shall be installed to allow inspection of the device status.
- 6. Refer to the Fire Alarm Sequence of Operations and Fire Alarm Operations Matrix for functions controlled by addressable control devices and slave relays.

2.15 DIGITAL ALARM COMMUNICATOR TRANSMITTERS (DACTs)

A. Performance Criteria:

- 1. Regulatory Requirements:
 - a. NFPA 72.

2. General Characteristics:

- a. DACT must be acceptable to remote central station and must be listed for fire alarm use.
- b. The system shall provide off premises communications capability using a DACT for sending system events to multiple Central Monitoring Station receivers as required.
- c. Functional Performance: Unit must receive alarm, supervisory, or trouble signal from FACU and automatically capture two telephone line(s) and dial preset number for remote central station. When contact is made with central station(s), signals must be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter must initiate local trouble signal and transmit signal indicating loss of telephone line to remote alarm receiving station over remaining line. Transmitter must automatically report telephone service restoration to central station. If service is lost on both telephone lines, transmitter must initiate local trouble signal.
 - 1) Connection to Telephone System: Furnish and install two (2) 4-pair Category 3 cables in 3/4-inch conduit from digital alarm communicator transmitter to telephone service demarcation point. All cabling, connectors, and field terminations shall be provided in accordance with the manufacturer's recommendations and/or as required to achieve the specified functional performance of the transmitter. Determine complete requirements, including routing, prior to bidding.
 - 2) Point-Specific Alarm Reporting: Include the hardware, software, and programming necessary to transmit a unique identification code for each initiating device corresponding to its description and location using the Owner's actual room names, numbers, and defined zones. This signal shall be transmitted to the Owner's security monitoring agency in the format/protocol specified by the local fire department. This contractor shall coordinate exact requirements directly with the local fire department. All labor and materials required for full compliance shall be included in this contract.
- d. Local functions and display at DACT must include the following:
 - 1) Verification that both telephone lines are available.
 - 2) Programming device.
 - 3) LED display.
 - 4) Manual test report function and manual transmission clear indication.
 - 5) Communications failure with central station or FACP.
- e. Digital data transmission must include the following:
 - 1) Address of alarm-initiating device.
 - 2) Address of supervisory signal.
 - 3) Address of trouble-initiating device.
 - 4) Loss of ac supply.
 - 5) Loss of power.
 - 6) Low battery.

- 7) Abnormal test signal.
- 8) Communication bus failure.
- f. Secondary Power: Integral rechargeable battery and automatic charger.
- g. Performance Criteria:
 - 1) Self-Test: Conducted automatically every 24 hours with report transmitted to central station.
 - 2) The system shall provide the CMS(s) with point identification of system events using Contact ID (SIA DC-05) or SIA DCS protocols.
 - 3) The dialer shall support up to 255 individual accounts and to send account information to eight (8) different receivers, each having a primary and secondary telephone access number. System events shall be capable of being directed to one or more receivers depending on event type or location as specified by the system design.
 - 4) In the event of CPU failure of the fire alarm control unit during a fire alarm condition, the local DACT degrade mode shall transmit a general fire alarm signal to the CMS.
 - 5) The system shall provide the Central Monitoring Station with point identification of system events using Contact ID protocols.
 - 6) Up to 8 eight communication services shall be supported per module. Up to 10 modules shall be supported per system. System events shall be capable of being directed to one or more receivers depending on event type or location as specified by the system design.
 - 7) The transmission to the Central Station shall be over conventional telephone lines.

2.16 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. All cabling and wiring associated with the fire alarm system shall be plenum-rated.
- C. All cabling and wiring associated with the fire alarm system shall be installed in conduit, unless it is supported open above accessible ceilings entirely concealed from all viewing angles below.
- D. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
 - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70 Article 760, Classification CI, for power-limited fire alarm signal service. UL listed as Type FPL and complying with requirements in UL 1424 and in UL 2196 for a 2-hour rating.
- E. 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.

3. Multiconductor Armored Cable: NFPA 70 Type MC, copper conductors, TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, UL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

2.17 MAGNETIC DOOR HOLDERS

- A. Magnetic door holders are furnished under Section 087100 "Door Hardware". Provide all connections for a complete working system.
- B. Coordinate voltage requirements with door hardware supplier.
- C. Magnetic door holders do not need to remain energized during loss of primary power.

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 INSTALLATION OF EQUIPMENT

- A. Comply with NECA 305, NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire alarm equipment. Install electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 1. Devices placed in service before other trades have completed cleanup must be replaced.
 2. Devices installed, but not yet placed, in service must be protected from construction dust, debris, dirt, moisture, and damage in accordance with manufacturer's written storage instructions.
- B. Install wall-mounted equipment, with tops of cabinets not more than 78-inches above finished floor, except FAA units, which shall be mounted 56-inches above the finished floor to the bottom of its enclosure.
- C. Manual Fire Alarm Pull Stations:

1. Install manual fire alarm pull stations in normal path of egress within 5'-0" of exit doorway.
 2. Mount manual fire alarm pull station on background of contrasting color.
- D. Operable part of manual fire alarm pull station must be between 42- and 48-inches above floor level. Devices must be mounted at same height unless otherwise indicated.
- E. Smoke- and Heat-Detector Spacing:
1. Comply with "Smoke-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
 2. Comply with "Heat-Sensing Fire Detectors" section in "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 3. Smooth ceiling spacing must not exceed the rating of the detector.
 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas must be determined in accordance with Annex A or Annex B in NFPA 72.
 5. HVAC: Locate detectors not closer than 36-inches from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12-inches from lighting fixture and not directly above pendant mounted or indirect lighting.
- F. Install cover on each smoke detector that is not placed in service during construction. Cover must remain in place except during system testing. Remove cover prior to system turnover.
- G. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend full width of duct. Tubes more than 36-inches long must be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
 2. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 3. Install supply-air smoke detectors at a suitable location in the duct on the downstream side of filters (when present).
 4. Install return-air smoke detectors at a suitable location in the duct prior to exhausting from the building or being diluted by outside air.
 5. Where possible locate detectors after bends or inlets, which will create turbulence, at, approximately six duct widths downstream from the source of the turbulence. Carefully review the detector manufacturer's installation instructions and consult with the factory representative for additional direction.
 6. Install sampling tubes so they extend the full width of the duct.
- H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in un-sprinklered elevator shafts.
- I. Remote Status and Alarm Indicators: Install in visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

- J. Audible Alarm-Indicating Devices: Install wall-mounted devices not less than 6-inches below ceiling. Install devices on flush-mounted back boxes with device-operating mechanism concealed behind grille. Install devices at same height unless otherwise indicated.
- K. Visible Alarm-Indicating Devices: Install wall-mounted devices adjacent to audible notification device and at least 6-inches below ceiling. Install devices at same height unless otherwise indicated.
- L. Ceiling-Mounted Voice/Tone Notification Speakers: Devices installed in a ceiling grid shall be recessed and positioned at the center of the ceiling tile. Corridor devices shall be mounted in a straight row, unless otherwise indicated.
- M. Device Location-Indicating Lights: Locate in public space near device they monitor.
- N. Smoke Dampers: Provide 120 VAC, 24 VAC, or 24 VDC power, whichever is required, and associated initiating devices and control devices. Provide fire alarm system control as indicated on the Fire Alarm Operations Matrix.
- O. Additionally, this contractor shall coordinate the connection of the smoke damper circuit through a BAS control relay (provided by temperature control contractor), which shall close the damper (open its circuit) whenever its associated air-handling unit is shut-down by the BAS.
- P. Door Hold-Opens and Sliding/Coiling Fire Doors/Shutters. Provide 120 VAC, 24 VAC, or 24 VDC power, whichever is required, and associated initiating devices and control devices. Prior to bidding, this contractor shall coordinate exact requirements with fire alarm contractor, electrical subcontractors, general contractor, and the contractors furnishing the door hold-opens and fire doors. Provide complete interface with the fire alarm system as required and as indicated on the Fire Alarm Sequence of Operations.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

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

- 1. Nameplate must be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
- 2. Nameplate must be laminated acrylic or melamine plastic signs with black background and engraved white letters at least 1/2-inch high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Install nameplate for each control connection, indicating field control panel designation and I/O control designation feeding connection.

3.6 INSTALLATION OF RACEWAYS

- A. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

3.7 INSTALLATION OF WIRE AND CABLE

- A. Install wiring according to the following:
 - 1. NECA 1.
 - 2. TIA/EIA 568-A.
- B. General Requirements:
 - 1. Install cables within raceways per Division 26.
 - 2. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 3. Install all cabling within raceways in areas with exposed structure.
 - 4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 - 5. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and junction boxes; and terminal cabinets. Cables may not be spliced.
 - 6. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii.
 - 7. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- C. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used.
- D. Comply with NECA 1.
- E. General Requirements:
 - 1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
 - 2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.

3. Secure and support cables at intervals not exceeding 60 inches (1520 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
 5. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
- F. System devices and wiring shall be installed in accordance with NEC 110.3(B), 300.11(A), 300.15, and 300.16, including conductors that are terminated, spliced, or interrupted—in which case a junction box or conduit body is required. Wherever a device is mounted in or onto an accessible ceiling, provide a recessed junction box supported by the ceiling grid—not the ceiling tile. The box shall be securely fastened to steel bracing that is designed/listed/labeled to bridge the ceiling grid. Boxes must be provided with cable protection bushings at all open knockouts (NEC 300.16). Cables and raceways shall be supported neither by ceiling grids nor their support wires. Listed and labeled equipment, including all system devices, shall be installed in accordance with instructions included in the listing or labeling (NEC 110.3(B)).
- G. Devices containing end-of-line resistors shall be appropriately labeled. Devices should be labeled such that removal of the device is not required to identify the EOL device.
- H. Wiring Method: Install wiring in metal raceway according to Division 26 Section “Raceway and Boxes for Electrical Systems.”
1. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable
 2. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 3. Fire-Rated Cables: Use of 2-hour fire-rated fire alarm cables, NFPA 70 Types MI and CI, is permitted.
 4. All systems and system components listed to UL864 Control Units for Fire Protective Signaling Systems may be installed within a common conduit raceway system, in accordance with the manufacturer's recommendations. System components not listed to the UL864 standard shall utilize a separate conduit raceway system for each of the sub-systems.
 5. Fiber Optic Cable: Only glass filament cable permitted. Plastic filament fiber optic cables are not acceptable. LC connectors shall be used at all equipment terminations.
 6. Concrete floors shall be X-rayed prior to core drilling on post tension slabs. Verify with Owner on type of slab prior to bid.
- I. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring

diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- J. Cables and raceways shall be supported neither by ceiling grids nor their support wires.
- K. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- L. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- M. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the FACP and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.8 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 NRTL listed for use with fire-alarm system in this Section before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Supervisory connections at valve supervisory switches.

3.9 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire alarm system before making connections.
- B. Make addressable connections with supervised interface device to the following devices and systems. Install interface device less than 36-inches from device controlled. Make addressable confirmation connection when such feedback is available at device or system being controlled.
 - 1. Smoke dampers in air ducts of designated HVAC duct systems.

2. Magnetically held-open doors.
3. Supervisory connections at valve supervisory switches.
4. Data communication circuits for connection to building management system.

3.10 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 location visible from FACP.

3.11 SYSTEM DOCUMENTATION

- A. Provide the following at the Service Record Documents box:
 1. Physical copy of service manual, O&M system drawings, battery calculations, component data sheets and test & inspection records.
 2. Electronic copy of fire alarm system software, service manual, O&M system drawings, battery calculations and component data sheets as submitted to local AHJ.
 3. Spare cabinet keys.
 4. Complete all legend sheet information, including sign-off by installer and AHJ.

3.12 GROUNDING

- A. Ground FACP and associated circuits in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Ground shielded cables at control panel location only. Insulate shield at device location.

3.13 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- D. Tests and Inspections:
 1. Visual Inspection: Conduct visual inspection prior to testing.

- a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
 - b. Comply with "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 "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 and record voice intelligibility and audibility levels throughout each room or space. Wherever sound levels and intelligibility levels fail to meet or exceed code requirements, make all corrections, and describe measures taken to achieve code compliance.
6. Test visible appliances for the public operating mode according to manufacturer's written instructions.
7. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. The fire alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- I. 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.

3.14 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.
 1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.
 2. Train a minimum of ten (10) employees of Owner.
 3. Under this contract, conduct a total of twelve (12) hours (minimum) of on-site training as specified in instructions to Owner's employees in Division 01 Section "Demonstration

and Training.” Training shall be divided into two (2) separate sessions on two (2) separate days if requested by Owner. The first session shall provide two (2) hours of basic training. The second session shall provide eight (8) hours of in-depth training. Coordinate training agenda, dates, and times directly with Owner.

4. Conduct training on installed equipment after acceptance testing.
5. Train on system operation, including manual control of output functions from FACU.
6. Train on testing of system, including logging of system tests, field test of devices, and response to common troubles.
7. Refer to Division 01 Section “Demonstration and Training”, including requirements related to video recording.
8. Allow Owner to record training.

3.15 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three (3) visits to Project outside normal occupancy hours for this purpose for each building. Include a minimum of 12 hours of on-site labor designated for this purpose plus all necessary travel time and expenses.
- B. Annual Test and Inspection: Through the first year after date of Substantial Completion, test the fire alarm system complying with the testing and visual inspection requirements in NFPA 72. Perform tests and inspections listed for monthly, quarterly, semiannual, and annual periods. Use forms developed for initial tests and inspections.

PART 4 - SEQUENCE OF OPERATIONS

4.1 FIRE ALARM SYSTEM OPERATIONS SCHEDULE

- A. Provide all components, cabling, hardware, software, programming, and accessories necessary to achieve a fully integrated, complete, and functional turnkey system in accordance with these specifications.
- B. Visual/Audible Voice General Alarm Notification: Activate audible/voice notification and visual notification appliances throughout the entire building.
- C. Supervisory Signal: Provide audible and visual supervisory alert only at system annunciator panels and BAS system.
- D. Trouble Signal: Show visual trouble signal only at the system annunciator panels and BAS system.
- E. Alarm Annunciation and Recording: Log events, display at every FACU and FAA panel, and archive to network cloud all system activity. Transmit signal to the BAS.
- F. Supervising Station: Program the digital alarm communicator transmitter to signal offsite monitoring agency and/or first responders. Coordinate with Owner to achieve this function.

Transmit all alarm, supervisory, and trouble signals, unless otherwise stated. Transmit point-specific alarm data per agency's specifications.

1. Point-specific alarm reporting: include the hardware, software, and programming necessary to transmit a unique identification code for each initiating device corresponding to its description and location using the Owner's actual room names, numbers, and defined zones. This signal shall be transmitted to the Owner's security monitoring agency in the format/protocol specified by the local fire department or first responder. This contractor shall coordinate exact requirements directly with the local fire department. All labor and materials required for full compliance must be included in this contract.
- G. Sprinkler Alarm Notification: Activate exterior sprinkler flow audible/visual notification appliance via addressable relay and slave relay energizing its circuit.
- H. Building Automation System: Transmit alarm, trouble, and supervisory signals to the BAS (also known as BMS, temperature controls, or DDC interface).
- I. Smoke and Fire/Smoke Dampers: Send signal for air distribution shutdown 10 seconds prior to releasing smoke dampers. To release (close) smoke dampers, open connected power circuit via addressable relay and slave relay as required.
1. A smoke damper installed in a hallway/corridor wall shall be released (closed) upon initiation of any one of the smoke detectors located throughout the same hallway/corridor contiguous to the rated fire/smoke barrier.
 2. Smoke dampers installed in non-corridor walls shall be activated upon initiation of a dedicated duct-type smoke detector provided specifically for that single smoke damper or room smoke detectors (spot-type ceiling mounted) located on either side of the wall, whichever method is indicated on the Drawings.
- J. Air Distribution Control: Shutdown HVAC units/fans as indicated on the Drawings (see equipment connections schedules) via addressable relay and slave relay interfaced with each motor control circuit.
- K. Elevator Shutdown: Energize the electric actuator circuit (the breaker's shunt-trip mechanism) via addressable relay and slave relay to open the elevator power feeder. Also, provide continuous voltage monitoring of electric actuator circuit using a general-purpose power relay in conjunction with an addressable monitoring device. If circuit actuator is furnished integral to the local maintenance disconnect serving the elevator, instead, provide a N.C. control contact that opens and signals to the controller that the feeder was opened due to an activated heat detector (rather than for maintenance purposes). This is applicable where an emergency return unit is provided with the elevator.
- L. Elevator Recall: Provide two (2) addressable relays and slave relays for each individual or grouped elevators to interface with each elevator controller. The first relay shall signal the elevator to return to its designated level. If smoke is detected in the main elevator lobby of the designated level, the second relay shall signal the elevator to return to its alternate level, instead.

- M. Elevator Cab Visual: Provide addressable relay and slave relay for each individual or grouped elevators to interface with each elevator controller. This relay shall cause the firefighter's cab visual ("not safe" alarm) to illuminate.
- N. Hoistway Dampers: Hoistway dampers, if applicable, shall not be operated automatically. Provide a programmable button located in each fire alarm annunciator panel for manual control of each hoistway damper via addressable relay and slave relay. A supervisory signal shall indicate when a hoistway damper is open.
- O. Food Service Equipment Shutdown: De-energize power circuits to all kitchen equipment positioned below the fire suppression hoods via addressable relay and slave relay interfaced with the control contactor and/or control relay serving each kitchen equipment. See the food service equipment schedule on the Drawings for additional information.
- P. Intercom System, PA Systems, Classroom Audio Enhancement Systems: Silence all sound reinforcement systems. Coordinate muting interface with the manufacturer, supplier, and installer of each system.
- Q. Magnetic Door Hold-Opens: Release fire/smoke doors throughout building via addressable relays and slave relays. Refer to the Drawings for additional information.
- R. Fire/Smoke Partitions: Release coiling fire/smoke doors, fire/smoke curtains, or other electric-operated fire/smoke barriers as identified on the Drawings via addressable relay and slave relay.

4.2 FIRE ALARM SYSTEM OPERATIONS MATRIX

- A. Provide fully functional and complete fire alarm system in accordance with applicable codes, standards, and the Fire Alarm System Operations Matrix below.

FIRE ALARM OPERATIONS MATRIX																			
SYSTEM INPUTS	NOTIFICATION						FIRE SAFETY CONTROL OPERATIONS												
	GENERAL ALARM	SUPERVISORY ONLY	TROUBLE ONLY	ANNUNCIATOR PANEL	SUPERVISING STATION	SPRINKLER ALARM	SMOKE DAMPERS	AIR DISTRIBUTION CTRL	ELEVATOR SHUTDOWN	ELEVATOR RECALL	ELEVATOR CAB VISUAL	HOISTWAY DAMPER	KITCHEN SHUTDOWN	P.A. SYS / INTERCOM	CLASSROOM AUDIO	DOOR HOLD-OPENS	FS/S PARTITIONS		BAS
MANUAL PULL STATION	X			X	X									X	X	X			X
GENERAL DETECTION	X			X	X		X	X						X	X	X			X

FIRE ALARM OPERATIONS MATRIX																	
SYSTEM INPUTS	NOTIFICATION						FIRE SAFETY CONTROL OPERATIONS										
	GENERAL ALARM	SUPERVISORY ONLY	TROUBLE ONLY	ANNUNCIATOR PANEL	SUPERVISING STATION	SPRINKLER ALARM	SMOKE DAMPERS	AIR DISTRIBUTION CTRL	ELEVATOR SHUTDOWN	ELEVATOR RECALL	ELEVATOR CAB VISUAL	HOISTWAY DAMPER	KITCHEN SHUTDOWN	P.A. SYS / INTERCOM	CLASSROOM AUDIO	DOOR HOLD-OPENS	FS/S PARTITIONS
DUCT-TYPE: FS/S DAMPERS		X		X			X	X									X
AREA-TYPE: FS/S DAMPERS	X			X	X		X	X						X	X	X	X
DUCT-TYPE: FAN SHUTDOWN		X		X			X	X									X
ELEVATOR LOBBY SMOKE	X			X	X		X	X		X				X	X	X	X
ELEV RM/HOISTWAY SMOKE	X			X	X		X	X		X	X			X	X	X	X
ELEV RM/HOISTWAY HEAT	X			X	X		X	X	X					X	X	X	X
SHUNT-TRIP MONITORING		X		X													X
HOISTWAY MAN. DAMPER		X		X								X					X
FS/S PARTITION SMOKE	X			X	X		X	X						X	X	X	X
SPRINKLER FLOW OR PIV	X			X	X	X	X	X						X	X	X	X
SPRINKLER TAMPER/OS&Y		X		X													X
HOOD SUPPRESSION SYSTEM	X			X	X		X	X					X	X	X	X	X
CARBON MONOXIDE DET.		X		X													X
FACP AC POWER FAILURE		X		X													X
FACP LOW BATTERY			X	X													X

FIRE ALARM OPERATIONS MATRIX																	
SYSTEM INPUTS	NOTIFICATION						FIRE SAFETY CONTROL OPERATIONS										
	GENERAL ALARM	SUPERVISORY ONLY	TROUBLE ONLY	ANNUNCIATOR PANEL	SUPERVISING STATION	SPRINKLER ALARM	SMOKE DAMPERS	AIR DISTRIBUTION CTRL	ELEVATOR SHUTDOWN	ELEVATOR RECALL	ELEVATOR CAB VISUAL	HOISTWAY DAMPER	KITCHEN SHUTDOWN	P.A. SYS / INTERCOM	CLASSROOM AUDIO	DOOR HOLD-OPENS	FS/S PARTITIONS
FACP CKT MALFUNCTION			X	X													X

END OF SECTION 284600

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Protection of existing trees indicated to remain.
2. Removal of trees and other vegetation within the "Limits of Work" that are not designated on reference drawings to "remain."
3. Topsoil stripping.
4. Clearing and grubbing.
5. Removing above- and below-grade site improvements that interfere with new construction or that are shown to be removed on the contract drawings.
6. Dust control.
7. Protection of all existing improvements and utilities shown to remain.
8. Disconnecting, capping or sealing, and abandoning or removing site utilities in place.

1.2 RELATED SECTIONS

A. The following sections contain requirements that relate to this Section:

1. Earth Moving

1.3 PROJECT CONDITIONS

A. Traffic: Conduct site-clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities.

1. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated to remain in place.

1. Protect improvements on adjoining properties and on Owner's property.
2. Restore damaged improvements to their original condition, as acceptable to owner.

C. Protection of Existing Trees and Vegetation: Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking or skinning of roots, skinning or bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within

drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Provide temporary guards to protect trees and vegetation to be left standing.

1. Water trees and other vegetation to remain within limits of contract work as required to maintain their health during course of construction operations.
 2. Provide protection for roots over 1-1/2 inch (38 mm) in diameter that are cut during construction operations. Coat cut faces with an emulsified asphalt or other acceptable coating formulated to use on damaged plant tissues. Temporarily cover exposed roots with wet burlap to prevent roots from drying out; cover with earth as soon as possible.
 3. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations in a manner acceptable to Owner's Representative. Employ a licensed arborist to repair damage to trees and shrubs.
 4. Replace trees that cannot be repaired and restored to full-growth status, as determined by arborist.
- D. Salvable Improvements: Carefully remove items indicated to be salvaged and store where indicated or directed by Owner's Representative.
- E. Dust Control: Contractor shall contain particulate debris generated by his work activities from polluting the atmosphere or waterways.
- F. Blasting will not be permitted.

1.4 EXISTING SERVICES

- A. General: The information concerning the location of existing utilities as shown on the contract drawings have been taken from the records of the various utility companies and from field locations as marked by locators representing said utility companies. These locations are not to be construed as accurate or exact. Utility locations shall be verified in the field by the Contractor, prior to the commencement of construction.
- B. Arrange and pay for disconnecting, removing, capping, and plugging utility services. Notify affected utility companies in advance and obtain approval before starting this Work.
- C. Place markers to indicate location of disconnected services. Identify service lines and capping locations on Project Record Documents.
- D. Protect all existing utilities shown to remain.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SITE CLEARING

- A. General: Remove trees, shrubs, grass, and other vegetation, improvements, or obstructions, as required, to permit installation of new construction. Remove similar items elsewhere on site or premises as specifically indicated. Removal includes digging out and off-site disposal of stumps and roots.
 - 1. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
- B. Topsoil: Topsoil is defined as friable clay loam surface soil found in a depth of not less than 4 inches (100 mm). Satisfactory topsoil is reasonably free of subsoil, clay lumps, stones, and other objects over 2 inches (50 mm) in diameter, and without weeds, roots, and other objectionable material.
 - 1. Strip topsoil and store in designated location on site for re-use.
 - 2. Limit height of topsoil stockpiles to 72 inches.
 - 3. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - a. Where existing trees are indicated to remain, leave existing topsoil in place within drip lines to prevent damage to root system.
- C. Clearing and Grubbing: Clear site of trees, shrubs, and other vegetation, except for those indicated to be left standing.
 - 1. Completely remove stumps, roots, and other debris protruding through ground surface.
 - 2. Use only hand methods for grubbing inside drip line of trees indicated to remain.
 - 3. Fill depressions caused by clearing and grubbing operations with satisfactory soil material, unless further excavation or earthwork is indicated.
 - a. Place fill material in horizontal layers not exceeding 8 inches loose depth, and thoroughly compact each layer according to Section 312000 EARTH MOVING.
 - 4. All organic or other deleterious materials shall be removed from the project site prior to construction. Areas containing such material shall be overexcavated and reconstructed with engineered fill according to the requirements of Section 312000 EARTH MOVING.
- D. Removal of Improvements: Remove existing above-grade and below-grade improvements as indicated and as necessary to facilitate new construction.
 - 1. Abandonment or removal of certain underground pipe or conduits is indicated on site utility drawings and is included under work of related Division 22 and 26 Sections. Removing abandoned underground piping or conduits interfering with construction is included under this Section.
 - 2. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

- a. Unless existing full-depth joints coincide with the line of demolition, neatly saw-cut the length of existing pavement to remain before removing the existing pavement. Saw cut faces vertically.
- b. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.2 DISPOSAL OF WASTE MATERIALS

- A. Burning on Owner's Property: Burning is not permitted on Owner's property.
- B. Removal from Owner's Property: Remove waste materials from Owner's property and dispose of legally.

3.3 ENVIRONMENTAL PROTECTION

- A. Prevent debris, soil erosion, pollutants and all other unacceptable material from entering the existing storm and sanitary sewer systems. Prevent dust, smoke or other air borne material from polluting the atmosphere.

3.4 MONUMENT PROTECTION

- A. Monuments, bench marks and other reference features bounding this project shall be protected. Should these be disturbed in any manner, the Contractor shall have them replaced as approved by the Owner with no additional cost to the Owner.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Preparing and grading subgrades for slabs-on-grade, walks, pavements, and landscaping.
2. Excavating and backfilling for buildings and structures.
3. Drainage and moisture-control fill course for slabs-on-grade.
4. Subbase course for walks and pavements.
5. Subsurface drainage backfill for walls and trenches.
6. Excavating and backfilling trenches within building lines.
7. Excavating and backfilling for underground mechanical and electrical utilities and appurtenances.

B. Related Sections: The following Sections contain requirements that relate to this Section.

1. Division 31 Section "Site Clearing" for site stripping, grubbing, topsoil removal, tree protection and removal.
2. Division 32 Section "Portland Cement Concrete Paving" for proof rolling bases or subbases.
3. Division 03 Section "Cast-In-Place Concrete" for concrete encasings, cradles, and appurtenances for utility systems.

1.2 DEFINITIONS

- A. Excavation consists of the removal of material encountered to subgrade elevations and the reuse or disposal of materials removed.
- B. Subgrade: The uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials. Subgrade in lawn/landscape area, to receive topsoil in a separate contract, shall be 6" below finish grade.
- C. Borrow: Satisfactory soil material obtained off-site when sufficient approved soil material is not available from excavations.
- D. Subbase Course: The layer placed between the subgrade and base course in a paving system or the layer placed between the subgrade and surface of a pavement or walk.
- E. Base Course: The layer placed between the subbase and surface pavement in a paving system.
- F. Drainage Fill: Course of washed granular material supporting slab-on-grade placed to cut off upward capillary flow of pore water.

- G. Unauthorized excavation consists of removing materials beyond indicated subgrade elevations or dimensions without direction by the Owner's Representative. Unauthorized excavation, as well as remedial work directed by the Owner's Representative, shall be at the Contractor's expense.
- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below ground surface.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 1 Specification Sections.
- B. Product data for the following:
 - 1. Sieve analysis for drainage and moisture control fill materials.
- C. Test Reports: In addition to test reports required under field quality control, submit the following:
 - 1. Laboratory analysis of each soil material proposed for fill and backfill from on-site and borrow sources.
 - 2. One optimum moisture-maximum density curve for each soil material.
 - 3. Report of actual unconfined compressive strength and/or results of bearing tests of each stratum tested.
- D. Preexcavation Photographs or Video: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins.

1.4 QUALITY ASSURANCE

- A. Subsurface Investigations Report:
 - 1. The Contractor shall thoroughly familiarize himself with any subsurface investigations prior to bidding and start of work.
 - 2. All earthwork shall be performed in accordance with the recommendations in the aforementioned subsurface investigations and in compliance with applicable requirements of governing authorities having jurisdiction. The recommendations in the aforementioned subsurface recommendations and the applicable requirements of the governing authorities take precedence over the requirements listed in this specification section.
- B. The Owner has procured this report for his own use and the use of the Owner's Representative. Owner nor the Owner's Representative will assume responsibility for variations of subsurface soil quality or conditions at locations other than places shown at the time investigations were made. The Contractor shall be responsible for satisfying himself with respect to the means, methods and difficulty of earthwork operations.

- C. Testing and Inspection Service: All testing shall be the responsibility of the Contractor. An independent testing agency qualified according to ASTM E 329 to conduct soil materials and rock-definition testing, as documented according to ASTM D 3740 and ASTM E 548, shall be employed.
1. When tests indicate that the density of any layer of fill or portion thereof is below the specified density, such layer or portion shall be rejected until such time that corrective measures are taken necessary to comply with the Contract Documents. It shall be the sole responsibility of the Contractor to achieve the specified degree of compaction.
 2. Preinstallation Conference: Conduct conference at Project site.
 3. Before commencing earthwork, meet with representatives of the governing authorities, Owner, Owner's Representative, consultants, Geotechnical Engineer, independent testing agency, and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.

1.5 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt existing utilities serving facilities occupied by the Owner or others except when permitted in writing by the Owner or his Representative and then only after acceptable temporary utility services have been provided.
1. Provide a minimum 72-hours' notice to the Owner or his Representative and receive written notice to proceed before interrupting any utility.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shutoff services if lines are active.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. Satisfactory Soil Materials: Per Geotechnical Report or Geotechnical Engineer's recommendation.
- B. Unsatisfactory Soil Materials: Per Geotechnical Report or Geotechnical Engineer's recommendation.
- C. Subbase Under Street Pavements: Type 1 Aggregate (Rolled Stone) per Missouri Highway and Transportation Department (MHTD) Standards. Aggregate for Type 1 base shall be essentially limestone. The crushed stone shall not contain deleterious material such as shale or disintegrated stone in excess of 15 percent. Any silt and clay, and any deleterious material shall be uniformly distributed throughout the mass. The aggregates shall conform to the following gradation requirements:
1. Percent

- | | | |
|----|----------------------|-------|
| 2. | Passing 1 inch sieve | 100 |
| 3. | Passing ½ inch sieve | 60-90 |
| 4. | Passing No. 4 sieve | 40-60 |
| 5. | Passing No. 40 sieve | 15-35 |

- D. Impervious Fill: Clayey 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, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick minimum, 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 (750 mm) deep.

1. Tape Colors: Provide tape colors to utilities as follows:

- a. Red: Electric.
- b. Yellow: Gas, oil, steam, and dangerous materials.
- c. Orange: Telephone and other communications.
- d. Blue: Water systems.
- e. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
- B. Protect subgrades and foundation soils against freezing temperatures or frost. Provide protective insulating materials as necessary.
- C. Provide erosion control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.2 DEWATERING

- A. Prevent surface water and subsurface or groundwater from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

3.3 EXCAVATION

- A. Explosives: Do not use explosives.
- B. Unclassified Excavation: Excavation is unclassified and includes excavation to required subgrade elevations regardless of the character of materials and obstructions encountered.

3.4 STABILITY OF EXCAVATIONS

- A. Comply with local codes, ordinances, and requirements of authorities having jurisdiction to maintain stable excavations.

3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to required elevations and dimensions within a tolerance of plus or minus 1.2 inches (30 mm). Extend excavations a sufficient distance from structures for placing and removing concrete formwork, installing services and other construction, and for inspections.
 - 1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
 - 2. Bearing soils in the foundation excavation should not be disturbed or allowed to become extremely wet or dry. Foundation bearing surfaces shall be free of loose soil, standing water, and be level. Deleterious materials or isolated soft spots within the foundation shall be over excavated to suitable base and filled to design bearing elevation with lean concrete. Foundation excavation, inspection and concrete placement shall occur on the same day.
 - 3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Appurtenances: Excavate to elevations and dimensions required within a tolerance of plus or minus 1 inch. (30 mm). Do not disturb bottom of excavations intended for bearing surface.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated cross sections, elevations, and grades.

3.7 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated slopes, lines, depths, and invert elevations.
 - 1. Excavate trenches to uniform widths to provide a working clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches (300 mm) higher than top of pipe or conduit, unless otherwise indicated.
 - a. Clearance: 12 inches (300 mm) each side of pipe or conduit.
 - b. Length of Open Clearance: The Contractor shall not open more trench in advance of construction than necessary to expedite the work. Three hundred (300) feet will be the maximum length of open trench allowed.

- c. Trench Bracing: Wherever necessary to prevent caving, the excavation shall be adequately sheeted, braced and drained so that workmen may work therein safely and efficiently. The adequacy of trench bracing for safety shall be the Contractor's sole responsibility.
2. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove stones and sharp objects to avoid point loading.
3. Do not perform trench excavation in areas to receive fill until fill operations are complete to an elevation of not less than 24 inches above the top of the proposed pipe or conduit for which the trench is to receive.

3.8 APPROVAL OF SUBGRADE

- A. Notify Owner's Representative and testing agency when excavations have reached required subgrade. Approval by the Owner's Geotechnical Engineer will be required prior to concrete placement or utility installation.
- B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Owner's Representative.

3.9 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending indicated bottom elevation of concrete foundation or footing to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position when acceptable to the Owner's Representative.
 1. Fill unauthorized excavations under other construction as directed by the Owner's Representative.
- B. Where indicated widths of utility trenches are exceeded, provide stronger pipe, or special installation procedures, as required by the Owner or his Representative.

3.10 STORAGE OF SOIL MATERIALS

- A. Stockpile excavated materials acceptable for backfill and fill soil materials. Stockpile soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent wind-blown dust.
 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.11 BACKFILL

- A. Backfill excavations promptly, but not before completing the following:
1. Acceptance of construction below finish grade including, where applicable, damp proofing, waterproofing, and perimeter insulation.
 2. Surveying locations of underground utilities for record documents.
 3. Testing, inspecting, and approval of underground utilities.
 4. Concrete formwork removal.
 5. Removal of trash and debris from excavation.
 6. Removal of temporary shoring and bracing, and sheeting.
 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
 8. The Owner's Representative inspection.

3.12 UTILITY TRENCH BACKFILL

- A. Place and compact bedding course on rock and other unyielding bearing surfaces and to fill unauthorized excavations. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints and fittings.
- B. Concrete backfill trenches that carry below or pass under footings and that are excavated within 18 inches (450 mm) of footings. Place concrete to level of bottom of footings.
- C. Provide 4 inch (100 mm) thick concrete base slab support for piping or conduit less than 30 inches (750 mm) below surface of roadways. After installation and testing, completely encase piping or conduit in a minimum of 4 inches (100 mm) of concrete before backfilling or placing roadway subbase.
- D. Place and compact the first 12 inches of backfill of satisfactory soil material or subbase material, free of particles larger than 1/2 inch (12 mm), to a height of 12 inches (300 mm) over the utility pipe or conduit.
1. Carefully compact material under pipe haunches and bring backfill evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of utility system.
- E. Coordinate backfilling with utilities testing.
- F. Fill voids with approved backfill materials as shoring and bracing, and sheeting is removed.
- G. Final backfill shall be in equal increments the length and girth of the trench line.
- H. Backfilling of trenches shall be compacted with such equipment as may be required to obtain a minimum density of 95% of maximum dry density according to ASTM D 698 and as specified in Article "3.14 COMPACTION" of this Section.
- I. The density tests shall be performed at various depths in the trench to ensure that the minimum density is obtained throughout. For trenches of greater than 8 feet depth but less than 12-foot

depth, density tests shall be taken at 1/2 the trench depth. For trenches of 12-foot depth or greater, density tests shall be taken at the 1/3 and 2/3 depth levels.

- J. The frequency of density tests shall be a minimum interval of 500 lineal feet of mainline trench and at a minimum of one service line test per each 500 lineal feet of mainline installed. The number of density tests may be increased if directed by the Owner's Representative.
- K. Trench lines shall be restored to the original grade. Any excess soil shall be piled on top of the trench and shall be well tamped. The premises should be left in clean condition and all rock and debris shall be removed from the site. Pavement or walk cuts shall be repaved with material identical to the original surfaces.
- L. Install warning tape directly above utilities, 12 inches (300 mm) below finished grade, except 6 inches (150 mm) below subgrade under pavements and slabs.

3.13 FILL

- A. Preparation: Remove vegetation, frozen soil, topsoil, debris, wet, and unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placing fills.
 - 1. Plow strip or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing surface.
 - 2. Fill areas shall be proof rolled with a fully loaded tandem dump truck to help identify any soft or unsuitable areas. Areas identified as unsuitable shall be over excavated and reconstructed with engineered fill as specified in the subsurface investigations report.
- B. When subgrade or existing ground surface to receive fill has a density less than that required for fill as determined by the Owner's Geotechnical Engineer, break up ground surface to depth required, pulverize, moisture-condition or aerate soil and recompact to required density.
 - 1. Place fill material in 8-inch thick layers to required elevations for each location listed below.
 - a. Under grass, use satisfactory excavated or borrow soil material.
 - b. Under walks and pavements, use base material.
 - c. Under street pavements, asphaltic concrete pavements and slabs on grade, use required subbase material.
 - d. Under steps and ramps, use subbase material.
 - e. Under footings and foundations, use engineered fill as specified in the subsurface investigations report.
 - 2. Effective spreading equipment shall be used on each lift to obtain a uniform lift thickness prior to compaction.
 - 3. Fill layers shall be placed approximately parallel to the finished grade.
 - 4. Fill and subgrade construction shall not be started on foundation soil, partially completed fill, or subgrades that contain frost or ice.

3.14 MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill layer before compaction to within -2 to +4 percent of optimum moisture content as described by ASTM D 698.
 - 1. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace or scarify and air-dry satisfactory soil material that is too wet to compact to specified density.
 - a. Stockpile or spread and dry removed wet satisfactory soil material at location or locations approved by the Owner's Representative. Drying may be assisted by disking, harrowing, or pulverizing until the moisture content is reduced to a satisfactory value.

3.15 COMPACTION

- A. Place backfill and fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers. Each lift shall be compacted to the minimum density specified.
- B. Place backfill and fill materials evenly on all sides of structures to required elevations. Place backfill and fill uniformly along the full length of each structure.
- C. Percentage of Maximum Dry Density Requirements: Compact soil lift to not less than the recommended percentages of maximum dry density found in the Geotechnical Report, according to ASTM D 698.

3.16 GRADING

- A. General: Uniformly grade areas to a smooth surface, free from irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 - 1. Provide a smooth transition between existing adjacent grades and new grades.
 - 2. Cut out soft spots, fill low spots, and trim high spots to conform to required surface tolerances.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 - 1. Lawn or Unpaved Areas: Plus or minus 0.10 foot.
 - 2. Walks: Plus or minus 0.10 foot.
 - 3. Pavements: Plus or minus 1/2 inch.
- C. Grading Inside Building Lines: Finish subgrade to a tolerance of 1/2 inch (13 mm) when tested with a 10-foot (3 m) straightedge.

3.17 SUBBASE AND BASE COURSES

- A. Under pavements and walks, place subbase course material on prepared subgrades. Place base course material over subbases to pavements.
 - 1. Compact subbase and base courses at optimum moisture content to required grades, lines, cross sections and thickness to not less than 95 percent of ASTM D 698 relative density.
 - 2. Shape subbase and base to required crown elevations and cross-slope grades.
 - 3. When thickness of compacted subbase or base course is 6 inches (150 mm) or less, place materials in a single layer.
 - 4. When thickness of compacted subbase or base course exceeds 6 inches (150 mm), place materials in equal layers, with no layer more than 6 inches (150 mm) thick or less than 3 inches (75 mm) thick when compacted.

3.18 DRAINAGE FILL

- A. Under slabs-on-grade, place drainage fill course on prepared subgrade.
 - 1. Prior to placement of drainage fill, the entire slab area shall be proof rolled with heavy construction equipment, such as a fully loaded tandem dump truck, to identify any isolated soft areas. Proof-rolling shall be performed in the presence of a qualified geotechnical engineer. If soft areas are identified, they shall be recompacted as engineered fill.
 - 2. The slab subgrade soils shall be prevented from drying excessively or becoming overly wet prior to or during construction of the floor slab. Should slab subgrade soils be found to be unsuitable or become disturbed by nature or construction activities, these areas shall be excavated to a solid base, the material reworked, recompacted, and regraded as controlled engineered fill as specified in the subsurface investigations report.
 - 3. Compact drainage fill to required cross sections and thickness.
 - 4. Drainage fill shall be a minimum of 6" thick free draining, granular fill or as called out in the Geotechnical Report.

3.19 FIELD QUALITY CONTROL

- A. Testing Agency Services: Allow Owner's testing agency to inspect and test each subgrade and each fill or backfill layer. Do not proceed until test results for previously completed work verify compliance with requirements. Owner will only pay for those tests which pass; Design/Build Contractor shall pay for tests which do not pass.
 - 1. When the testing agency reports that subgrades, fills, or backfills are below specified density, scarify and moisten or aerate, or remove and replace soil to the depth required, recompact and retest until required density is obtained.

3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

- B. Repair and re-establish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace material to depth directed by the Owner or his Representative; reshape and recompact at optimum moisture content to the required density.
- C. Settling: Where settling occurs during the Project correction period, remove finished surfacing, backfill with additional approved material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to the greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Disposal: Remove surplus satisfactory soil to or owner designated area and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION 312000

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SECTION 316615 – HELICAL PILES

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. Requirements for delegated design of helical pile system.

1.3 SCOPE

- A. The work consists of designing, furnishing, installing, and testing helical piles used to support foundation loads (compression and lateral) according to the project plans provided and these specifications. Unless otherwise noted, the installing contractor shall provide all labor, tools, equipment and materials necessary to install the required piles.
- B. The Contractor will provide suitable access to the construction site for the installing contractor's personnel and equipment. Unless specifically noted otherwise in the contract documents, the general contractor will remove and replace any structures, utilities, pavements, landscaping or other surficial improvements in the work area as necessary to facilitate the work. The general contractor will be responsible for overall construction oversight to minimize potential for developing unsafe conditions. The work may include post-construction monitoring of pile performance if required by the Owner or the pile designer to confirm performance of the piles subsequent to their installation. The work may also include installation of additional piles if the initial installation does not meet specified capacity or performance requirements. The Owner is responsible for providing the installing contractor with all available subsurface soils, rock and groundwater information and geotechnical testing data.

1.4 DEFINITIONS

- A. Several commonly used design and construction terms are defined below. Helical piles are installed by screwing the pile assembly into the soils with crowd to resist applied loads through bearing of the helical plates and skin friction on the shaft (as applicable) in the soil in which they are embedded.
 - 1. Bearing Stratum: The soil or rock layer which provides the axial resistance for the installed helical pile.

2. Crowd: Axial compressive force or pressure applied to the helical pile as needed during installation to ensure the pile advances into the ground a minimum of 80% of the distance equal to the helix pitch for each rotation.
3. Deflection: The displacement of the pile as measured at the pile head.
4. Effective Torsional Resistance: The average installation torque, typically taken over a distance equal to the last three diameters of penetration of the largest helix plate in the specified bearing stratum.
5. Extension Section: Helical pile component that connects the lead section to the load transfer device.
6. Geotechnical Resistance: The maximum load that can be resisted through the bearing of the helix plates and skin friction on the shaft (as applicable) in the soil or rock in which they are embedded without exceeding the specified performance criteria.
7. Helical Pile: Consists of 1) one or more helix plates attached to the central shaft and 2) load transfer device for attachment to a structure/footing element.
8. Helix Plate (helices/helix): Generally round steel plate formed into a helical spiral and welded to the central shaft.
9. Installation Angle: The angle of inclination between the longitudinal axis of the helical pile and the horizontal.
10. Lead Section: The first helical pile component installed into the soil. It consists of one or more helix plates.
11. Limit State: A condition beyond which a helical pile component or interface becomes no longer useful for its intended function (serviceability limit state) or to be unsafe (strength limit state).
12. Loads: Forces or other actions as defined by the Owner/Owner's representative that must be resisted by the piles.
13. Load Test: A procedure to test the capacity and relation of load to deflection by applying a load (compression, tension, and/or lateral) on the helical pile.
14. Mechanical Strength: The maximum compressive, tension, and/or lateral load that can be resisted by the structural elements of a helical pile.
15. Reveal: The distance from the ground surface to the end of the last installed extension of a pile, measured along the piles longitudinal axis.
16. Pitch: The distance measured along the axis of the shaft between the leading and trailing edges of the helix plat.
17. Safety Factor (Factor of Safety): The ratio of the ultimate resistance to the service load used for the design of any helical pile component or interface.
18. Service Load: The total magnitude of the un-factored loads that must be resisted by the piles.
19. Torque: The measure of the rotational force times the moment arm needed to overcome the shear strength of the soil (ft-lb).
20. Ultimate Resistance: Limit state based on the lesser of mechanical strength or geotechnical resistance of the helical pile defined as the point at which no additional load can be applied without exceeding the specified performance criteria.

1.5 PRECONSTRUCTION SUBMITTALS

- A. The installing contractor and/or pile designer shall submit to the Owner/Owner's representative a proposal including the following submittals, in addition to other qualifications as listed in the overall project specifications/plans. Work shall not begin until all the submittals have been received and approved by the Owner/Owner's representative.

- B. Submittals as evidence of installing contractor's competence:
 - 1. Pile manufacturer's certificate of competency in installation of the manufacturer's helical piles.
 - 2. A list of at least three projects completed successfully within the previous five years wherein the installing contractor installed helical piles in comparable soil conditions and for service loads similar to those shown in the project plans. The list shall include names and contact information of those project owners' representatives who can verify the installing contractor's participation in those projects.
- C. Submittals as evidence of installing contractor's safety record, including a listing of all safety violations reported against the installing contractor within the previous three years and the current status or final resolutions thereof. Descriptions of safety improvements instituted within the previous three years may also be submitted, at the installing contractor's discretion.
- D. Submittals as evidence of pile designer's competence:
 - 1. A recommendation from the pile manufacturer, pile distributor, or manufacturer's representative.
 - 2. Proof of registration as a Professional Engineer registered in the State of Kansas
 - 3. A list of three projects completed within the previous five years wherein the pile designer designed helical piles for comparable soil conditions and for service loads similar to those shown in the project plans. The list shall include names and contact information of those project owners' representatives who can verify the designer's participation in those projects.
- E. Submittals as evidence of pile manufacturer's competence and capability:
 - 1. Proof of at least three years of production experience making helical piles.
 - 2. Proof that the manufacturer's helical piles have been used successfully in at least three engineered construction projects within the last five years.
 - 3. Product evaluation approved by the International Code Council Evaluation Services (ICC-ES).

1.6 DESIGN DOCUMENTATION SUBMITTALS

- A. The installing contractor and/or pile designer shall submit the following helical pile design documentation:
 - 1. Product designations for helix sections, extension sections, and all ancillary products to be supplied at each helical pile location.
 - 2. Individual pile service loads.
 - 3. Individual pile loading requirements (if any).
 - 4. Manufacturer's published mechanical strengths for the pile assemblies, including load transfer devices per current ICC-ES report, calculations, and/or full scale testing.
 - 5. Calculated geotechnical resistance of piles based on the Geotechnical Evaluation Report prepared by Braun Intertec under Project Number B1602857, dated July 7, 2016 and any supplemental geotechnical information obtained by the contractor.
 - 6. Minimum effective torsional resistance criteria.

7. Maximum allowable installation torque of pile.
8. Minimum embedment depth/length requirements as appropriate for the site soil profiles and project loading.
9. Proposed production quality control plan, including method and equipment to be used to measure torsional resistance during installation.
10. Procedures and acceptance criteria for load testing.
11. A design submittal prepared by the helical pile foundation designer which shows that the selected piles can be installed to achieve the performance requirements of the project plans and this specification.
12. Copies of certified calibration reports for torque measuring equipment and load measuring equipment to be used on the project. The calibrations shall be performed within 12 months of the proposed starting date for helical pile installation or as recommended by the equipment manufacturer based on the proposed starting date.

1.7 INSTALLATION RECORD SUBMITTALS

- A. The installing contractor shall provide the Owner/Owner's representative copies of individual helical pile installation records within 24 hours of each completed installation. Formal copies shall be submitted within one week of completion of the helical pile installation. These installation records shall include, but are not limited to:
 1. Date and time of installation.
 2. Installation equipment type and operator name.
 3. Plan location of helical pile.
 4. Pile reveal.
 5. As-built helical pile type and configuration.
 6. Total length of installed pile.
 7. As-built installation angle of pile.
 8. Average torque measurements over the last 5 feet of installed length, and final installed torque.
 9. Effective torsional resistance and calculated geotechnical resistance based on effective torsional resistance and/or as derived from the test pile program.
 10. Comments pertaining to interruptions, obstructions, or other relevant information.

1.8 QUALITY ASSURANCE

- A. Single-Source Responsibility for Pile Material: Obtain all helical pile materials from one source and by a single producer.
- B. Engineering Responsibility: Helical pile system shall be engineered by qualified professional engineer legally authorized to practice in jurisdiction where Project is located.
- C. Product Identification: All helical pile system members shall be clearly marked with manufacturer's name, product series, plant identification, date of manufacture, and code compliance, if applicable.

1.9 DESIGN AND PERFORMANCE REQUIREMENTS

- A. Helical piles shall be designed (overall pile length, helix configuration and minimum effective torsional resistance) to support the service loads with the applicable factor of safety as shown on the project plans
- B. Except where noted otherwise on the project plans, all pile components shall be designed to provide a minimum safety factor for mechanical strength of 2.0.
- C. Except where noted otherwise on the project plans, all piles shall be designed and installed to provide a minimum safety factor for ultimate applied load resistance of 2.0, a maximum axial deflection at service load of 0.5 inch, a maximum horizontal deflection at service load of 0.5 inch, and must satisfy the deflection criteria as stated on the plans.
- D. Except where noted otherwise on the project plans, each pile shall be designed to meet a corrosion service life of 50 years.
- E. The helical pile foundation design shall take into account pile spacing, soil stratification, long term soil consolidation, corrosion, settlement, and strain compatibility issues as are present for the project.
- F. If on-site load testing is to be performed, the piles shall be designed such that the maximum test load does not exceed 90 percent of the manufacturer's rated mechanical strength of any pile component or load transfer device.
- G. The pile design should include a comprehensive analysis and design of the existing footing including pile punching shear, edge distance, required reinforcement, and concrete strength.

PART 2 - EXECUTION

2.1 INSTALLATION, GENERAL

- A. Placement Requirements: Helical piles shall be placed such that the pile head is within 3 inches laterally and longitudinally and 1/2 inch vertically to plan; and the pile shaft alignment is within 2 degrees of the installation angle shown on the project plans.

2.2 PILE INSTALLATION

- A. Before entering the construction site to begin work, the installing contractor shall provide proof of insurance coverage as stated in the general specifications and/or contract.
- B. Installing contractor shall furnish and install all helical piles per the project plans and pile design documentation approved by the Owner/Owner's representative. In the event of conflict between the project plans and the approved pile design documentation, the installing contractor shall not begin construction on any affected items until such conflict has been resolved.

- C. The installing contractor shall conduct construction operations in a manner to ensure the safety of persons and property in the vicinity of the work. Personnel shall comply with safety procedures that are both in accordance with OSHA standards and specified in the project safety plan.
- D. The installing contractor shall request marking of underground utilities by an underground utility location service (Gopher State One Call and private utility locator as appropriate) and shall avoid contact with all marked underground utilities.
- E. The portion of the construction site occupied by the installing contractor, installing contractor's equipment, and installing contractor's material stockpiles shall be kept reasonably clean and orderly.
- F. Installation of helical piles shall be observed by the Special Inspector for quality assurance purposes. The installing contractor shall notify the Special Inspector at least 24 hours prior to pile installation operations.
- G. All helical pile sections and ancillary products shall be marked as necessary to allow for correlation with the pile design documentation.
- H. The helical pile installation technique shall be such that it is consistent with the geotechnical, logistical, environmental, and load carry conditions of the project. The lead section shall be positioned at the location as shown on the pile design drawings. The helical pile sections shall be engaged and advanced into the soil in a smooth, continuous manner. Sufficient crowd shall be applied to uniformly advance the helical pile sections a minimum of 80 percent of the distance equal to the pitch of the helix plate per revolution. The rate of rotation and magnitude of crowd shall be adjusted for different soil conditions and depth. Extension sections shall be provided to obtain the required minimum overall depth/length and minimum effective torsional resistance as shown on the project plans and/or helical pile design submittals.

2.3 TERMINATION CRITERIA

- A. The specified minimum overall depth/length criteria and minimum effective torsional resistance criterion must be satisfied prior to terminating the helical pile installation. In the event any helical pile fails to meet these production quality control criteria, the following pre-qualified remedies are authorized:
 - 1. If the installation fails to meet the minimum effective torsional resistance criterion at the minimum embedment depth/length:
 - a. Continue the installation to greater depth/length in the specified bearing stratum until the effective torsional resistance criterion is met. Or
 - b. Demonstrate acceptable pile performance through load testing. Or
 - c. Replace the pile with one having a different helix configuration. The replacement pile must either be embedded to a length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile and meet the minimum effective torsional resistance criterion, or pass load testing.

- B. If the torque measured during installation reaches the helical pile's allowable torque rating as defined in the design submittal prior to reaching the minimum embedment depth/length criterion, with approval from the Owner/Owner's representative, terminate the installation then proceed with one of the following recommended actions:
1. Replace the pile with one having a shaft with higher torsional strength rating. This replacement pile shall be installed to satisfy the minimum embedment depth/length criterion. The replacement pile must either be embedded to a length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile and meet the minimum effective torsional resistance criterion, or pass load testing.
 2. Replace or modify the pile with one having a different helix configuration with higher torsional strength rating. This replacement pile shall be installed to satisfy the minimum embedment depth/length criterion. The replacement pile must either be embedded to a length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile and meet the minimum effective torsional resistance criterion, or pass load testing.
 3. If approved by the Owner/Owner's representative, remove and reinstall the pile at a position at least three times the diameter of the largest helix away from the initial location. Original minimum depth/length and effective torsional resistance criteria must be met for the repositioned pile. This pile repositioning may require the installation of additional helical piles with service loads adjusted for the spacing changes.
- C. If a helical pile fails to meet acceptance criteria in a load test:
1. Install the pile to a greater depth/length and installation torque and re-test. Or
 2. Replace the pile with one having more and/or larger helix plates. This replacement pile shall be installed to satisfy the minimum embedment depth/length criterion. The replacement pile must either be embedded to a length that places its last helix at least three times its own diameter beyond the position of the first helix of the replaced pile and meet the minimum effective torsional resistance criterion. This pile shall be re-tested.
 3. If approved by the Owner's representative, reduce the load capacity of the helical pile and install additional piles. Additional piles must be installed at positions that are at least three times the diameter of the largest helix away from any other pile locations and are approved by the Owner's representative.
- D. Load testing to qualify a helical pile under the remedial actions outlined in Section 8 shall not be used to satisfy load testing requirements shown in the project plans or approved design submittals.
- E. If a helical pile fails a production quality control criterion for any other reason, including damage during installation, any proposed remedy must be approved by the Owner/Owner's representative prior to implementation.
- F. Within one week of completion of the work, the installing contractor shall remove any and all material, equipment, tools, debris, or other items belonging to the installing contractor or used under the installing contractors direction.

2.4 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
1. Verify pile materials, sizes, and lengths comply with the requirements.
 2. Verify placement locations and plumbness.
 3. Observe pile installation and record the installation equipment used, pile dimensions, tip elevations, final depth, final installation torque and other pertinent installation data as required by the pile designer.
 4. Observe and document load tests in accordance with the applicable standard(s) and requirements of the pile designer.
- B. The Installing Contractor shall furnish all labor, equipment and preproduction helical piles necessary to accomplish the testing as shown in the submitted and approved pile design submittals. The installing contractor shall apply the specified loads for the specified durations and record the specified data. No deviations from the test plan will be allowed without explicit approval in writing from the Owner/Owner's representative. Pile testing shall be in accordance with the load-testing procedures and performance requirements deemed suitable for the application by the Owner/Owner's representative, or pile designer.
- C. The installing contractor shall provide the Owner/Owner's representative copies of the field test data or reports within 24 hours after completion of each load test. Formal test reports shall be subsequently submitted by an engineer licensed in the State of Kansas in a timely manner. Formal test results shall include, but are not limited to:
1. Name of project and installing contractor.
 2. Name of installing contractor's supervisor during installation.
 3. Name of third party testing agency, if not the Special Inspector/Testing Agency.
 4. Type of test.
 5. Date, time, and duration of test.
 6. Unique identifier and location of the pile tested.
 7. Description of calibrated testing equipment and test set-up.
 8. Testing equipment calibration data.
 9. Actual helical pile type and configuration.
 10. Reaction frame/pile installation and verification data, as required by Owner or pile designer.
 11. Steps and duration of each load increment.
 12. Incremental and cumulative pile-head deflections at each load step.

END OF SECTION 316615

SECTION 321216 - HOT-MIX ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Hot-mix asphalt paving.
2. Hot-mix asphalt patching.
3. Pavement-marking paint.
4. Cold milling of existing hot-mix asphalt pavement.

B. Related Sections include the following:

1. Division 31 Section Site Clearing for saw-cutting of edges of existing pavement.
2. Division 31 Section "Earth Moving" for aggregate subbase and base courses and aggregate pavement shoulders.
3. Division 32 Section Portland Cement Concrete Paving.
4. Division 32 Section "Paving Joint Sealants" for joint sealants and fillers at joints between concrete paving and asphalt paving.

1.2 SUBMITTALS

- A. Product Data: For each product specified. Include technical data and tested physical and performance properties.
- B. Material Certificates signed by material producer and Contractor, certifying that each material item complies with or exceeds specified requirements.
- C. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
- D. Pavement marking plan indicating pavement markings, lane separations, and defined parking spaces shall be prepared by the Contractor. Indicate dedicated handicapped spaces with international graphics symbol.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.
- B. Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.

1. Firm shall be a registered and approved paving mix manufacturer with the Missouri Highway and Transportation Department.
- C. Regulatory Requirements: Conform to Construction and material Specifications for Paving, Section 2200, Kansas City Metropolitan Chapter of American Public Works Association Standards and Specifications latest edition, together with Section 2200 of the Lee's Summit, Missouri Standard Specifications.
- D. Preinstallation Conference: Conduct conference at Project site. Review methods and procedures related to asphalt paving including, but not limited to, the following:
 1. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
 2. Review condition of substrate and preparatory work performed by other trades.
 3. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
 4. Review and finalize construction schedule for paving and related work. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
 5. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
 6. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location and within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.5 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities and in accordance with Owner approved traffic control plan. Obtain street closure permit for work within public right-of-way.
- B. Environmental Limitations: Do not apply asphalt materials if base is wet or contains an excess of moisture or if the following conditions are not met:
 1. Prime and Tack Coats: Apply prime and tack coats when ambient temperature is above 50 deg F (10 deg C) and when temperature has not been below 35 deg F (1 deg C) for 12 hours immediately prior to application.
 2. Asphalt Base Course: Air temperature above 40 deg F (minus 1 deg C) and rising at time of placement.

3. Hot-mixed Asphalt Surface Course: Atmospheric temperature above 60 deg F (4 deg C) at time of placement and when base is dry.
- C. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 40 deg F (4 deg C) for oil-based materials, 50 deg F (10 deg C) for water-based materials, and not exceeding 95 deg F (35 deg C).
- D. Grade Control: Establish and maintain required lines and elevations.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. General: Use locally available materials and gradations that comply with the requirements of the Kansas City Metropolitan Chapter APWA "Standard Specifications and Design Criteria" except as noted herein. Coarse Aggregate: Coarse aggregate shall be in accordance with MCIB Section 4 – paragraph 2, except that the total shale, clay, coal and lignite content shall not exceed 0.5 percent by weight.
- B. Fine Aggregate: Fine aggregate shall be in accordance with MCIB Section 4- Paragraph 3.

2.2 ASPHALT-AGGREGATE MIXTURE

- A. Hot-Mix Asphalt: Provide dense, hot-laid, hot-mix asphalt plant mixes complying with section 2200 of the Kansas City Metropolitan Chapter APWA "Standard Specifications and Design Criteria" and as recommended.
 1. Base Course: APWA Type 1-01.
 2. Surface Course: APWA Type 3-01.

2.3 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO MP 1, PG 64-22.
- B. Asphalt Cement: ASTM D 3381 for viscosity-graded material and ASTM D 946 for penetration-graded material.
- C. Prime Coat: Asphalt emulsion prime complying with KCMO, APWA requirements.
- D. Tack Coat: ASTM D 977, emulsified asphalt or ASTM D 2397, cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- E. Fog Seal: ASTM D 977, emulsified asphalt or ASTM D 2397, cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.
- F. Water: Potable.

- G. Undersealing Asphalt: ASTM D 3141, pumping consistency.

2.4 AUXILIARY MATERIALS

- A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.
- B. Sand: ASTM D 1073, Grade Nos. 2 or 3.
- C. Joint Sealant: ASTM D 3405, hot-applied, single-component, polymer-modified bituminous sealant.
- D. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than 3 minutes.
 - 1. Color: As indicated in the plan.
- E. Glass Beads: AASHTO M 247, Type 1.
- F. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 4-1/2 inches high by 9 inches wide by 72 inches long. Provide chamfered corners and drainage slots on underside and holes for anchoring to substrate.
 - 1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that subgrade is dry, free from all loose and foreign material and compacted to 95 percent standard maximum density
- B. Proof-roll subbase using heavy, pneumatic-tired rollers to locate areas that are unstable or need further compaction.
- C. Where base is rough and uneven, a leveling course shall be placed and compacted to 95 percent standard maximum density prior to placement of asphalt pavement courses.
- D. Notify Owner's Representative in writing of any unsatisfactory conditions. Do not begin paving installation until these conditions have been satisfactorily corrected.

3.2 COLD MILLING

- A. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
 - 1. Mill to a depth of 2 inches.

2. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
3. Control rate of milling to prevent tearing of existing asphalt course.
4. Repair or replace curbs, manholes, and other construction damaged during cold milling.
5. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
6. Transport milled hot-mix asphalt to asphalt recycling facility.

- B. Keep milled pavement surface free of loose material and dust.

3.3 SURFACE PREPARATION

- A. General: Immediately before applying asphalt materials, remove loose and deleterious material from compacted subbase surfaces. Ensure that prepared subgrade is ready to receive paving.
1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.
- B. Notify Owner's Representative of unsatisfactory conditions. Do not begin paving work until deficient subbase areas have been corrected and are ready to receive paving.
- C. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
1. Mix herbicide with prime coat if formulated by manufacturer for that purpose.
- D. Prime Coat: Apply uniformly over surface of compacted subgrade or compacted-aggregate base at a rate of 0.15 to 0.50 gal./sq. yd. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure and dry a minimum of 72 hours or as long as necessary to attain penetration and evaporation of volatile.
1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use just enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
 2. Protect primed subgrade from damage until ready to receive paving.
- E. Tack Coat: Apply to contact surfaces of previously constructed asphalt or Portland cement concrete and surfaces abutting or projecting into hot-mixed asphalt pavement. Distribute at a rate of 0.05 to 0.15 gal. per sq. yd. of surface.
1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
 2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.4 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt mix on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and compacted thickness.
 - 1. Place hot-mix Type 1-01 asphalt base course in thickness of lifts not to exceed 4 inches.
 - 2. Place hot-mix Type 3-01 asphalt surface course in single lift.
 - 3. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than 10 feet wide, unless otherwise acceptable to Owner or his Representative, and except where infill edge strips of a lesser width are required.
 - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete asphalt base course for a section before placing asphalt surface course.
- C. Immediately correct surface irregularities in paving course behind paver. Use shovel or lute to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

- A. Construct joints between old and new pavements, or between successive days' work, to ensure continuous bond between adjoining paving sections. Construct joints free of depressions with same texture, density and smoothness as other sections of hot-mix asphalt course.
 - 1. Clean contact surfaces and apply tack coat.
 - 2. Offset longitudinal joints in successive courses a minimum of 6 inches.
 - 3. Offset transverse joints in successive courses a minimum of 24 inches.
 - 4. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
 - 5. Compact asphalt at joints to a density within 2 percent of specified course density.

3.6 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving mixture will bear roller weight without excessive displacement. Compact hot-mix paving mixture with hot, hand tampers or vibratory-plate compactors in areas inaccessible to rollers.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Accomplish breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Repair displaced surfaces by loosening displaced material, filling with hot-mix asphalt, and rerolling to required elevations.

- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling, while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Base course shall have a minimum density of 95 percent. Surface course shall have a minimum density of 97 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while still hot, with back of rake or smooth iron. Compact thoroughly using tamper or other satisfactory method.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials. Remove paving course over area affected and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to be damaged by traffic loads.

3.7 INSTALLATION TOLERANCES

- A. Thickness: In-place compacted thickness tested in accordance with ASTM D-3549 will not be accepted if exceeding the following tolerances:
 - 1. Base Course: Plus or minus ½ inch.
 - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course: 1/4 inch.
 - 2. Surface Course: 1/8 inch.
 - 3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.
- C. Check surface areas at intervals as directed by Owner's Representative.

3.8 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Owner or his Representative.

- B. Allow paving to cure for 30 days before starting pavement marking.
- C. Cleaning: Sweep and clean surface to eliminate loose material and dust.
- D. Apply paint with mechanical equipment to produce pavement markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum of 12 to 15 mils dry thickness.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing agency to perform field inspections and tests and to prepare test reports.
 - 1. Testing agency will conduct and interpret tests and state in each report whether tested Work complies with or deviates from specified requirements.
 - 2. Contractor shall coordinate construction operations with Owner's testing agency.
- B. Additional testing, at Contractor's expense, will be performed to determine compliance of corrected Work with specified requirements.
- C. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- E. In-Place Density: Samples of uncompacted paving mixtures and compacted pavement will be secured by testing agency according to ASTM D 979.
 - 1. Reference laboratory density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 1559, and compacted according to job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
 - a. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
- F. Repair, or remove and replace, or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements as directed by Owner's Representative.

END OF SECTION 321216

SECTION 321313 - PORTLAND CEMENT CONCRETE PAVING

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 exterior portland cement concrete paving for the following:
 - 1. Curbs and gutters.
 - 2. Walkways.
 - 3. Driveways.
 - 4. Entrances
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 31 Section "Earth Moving" for subgrade preparation, grading and subbase course.
 - 2. Division 32 Section "Paving Joint Sealants" for joint fillers and sealants within concrete paving and at joints with adjacent construction.

1.3 SUBMITTALS

- A. General: Submit the following according to the Conditions of the Contract and Division 01 Specification Sections.
- B. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others.
- C. Design mixes for each class of concrete. Include revised mix proportions when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
- D. Pavement marking plan indicating lane separations and defined parking spaces will be prepared by the Contractor. Show dedicated handicapped spaces with international graphics symbol.
- E. Laboratory test reports for evaluation of concrete materials and mix design tests.
- F. Minutes of pre-installation conference.

1.4 QUALITY ASSURANCE

- A. Concrete Standards: Comply with provisions of the following standards, except where more stringent requirements are indicated.
 - 1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete for Buildings."
 - 2. Midwest Concrete Industry Board (MCIB).
 - 3. Concrete Reinforcing Steel Institute (CRSI) "Manual of Standard Practice."
 - 4. Missouri Standard Specifications for Highway Construction, Section 501 Concrete.
 - 5. Comply with applicable requirements of Kansas City Metropolitan Chapter, American Public Works Association, "Standard Specifications and Design Criteria – Division II; "Construction and Material Specifications for Paving" Section 2200 and "Incidental Construction" Section 02300.
 - a. Comply with applicable requirements of the City of Lee's Summit, Missouri, Department of Public Works, "Standard Specifications" Section 2200.
- B. Concrete Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
- C. Concrete Testing Service: Engage a qualified independent testing agency to perform materials evaluation tests and to design concrete mixes.
- D. Preinstallation Conference: Conduct conference at Project site.
 - 1. Before installing portland cement concrete paving, meet with representatives of authorities having jurisdiction, Owner and his Representative, consultants, independent testing agency, and other concerned entities to review requirements. Notify participants at least 3 working days before conference.

1.5 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities and in accordance with Owner approved Traffic Control Plan.
- B. Do not place concrete when subgrade, forms or equipment are wet or frozen or contain ice or snow. Cold weather concrete work, when the air temperature is below 40 degrees F., shall conform to MCIB Standard Concrete Specification, Section 10.
- C. Hot weather concrete work, when the air temperature is above 80 degrees F., shall conform to MCIB Standard Concrete Specification, Section 11.

PART 2 - PRODUCTS

2.1 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other acceptable panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
 - 1. Use flexible or curved forms for curves of a 100-foot or less radius.
- B. Form Release Agent: Provide commercial formulation form-release agent with a maximum of 350 g/L volatile organic compounds (VOCs) that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Fabric: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- B. Reinforcement Bars: ASTM A 615, Grade 60, deformed.
- C. Joint Dowel Bars: Plain steel bars, ASTM A 615, Grade 60. Cut bars true to length with ends square and free of burrs.
- D. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:
 - 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.3 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type I or II.
- B. Coarse aggregate shall conform to MCIB, Section 4. Only limestone from the Bethany Falls or Calloway ledges shall be used.
- C. Fine aggregate shall conform to MCIB Section 4.
- D. Water: Potable.

2.4 ADMIXTURES

- A. Provide concrete admixtures that do not contain chloride ions.

- B. Air-Entraining Admixture: ASTM C 260, certified by manufacturer to be compatible with other required admixtures.
- C. Water-Reducing Admixture: ASTM C 494, Type A.
- D. High-Range Water-Reducing Admixture: ASTM C 494, Type F or Type G.
- E. Water-Reducing and Retarding Admixture: ASTM C 494, Type D.

2.5 CURING MATERIALS

- A. Liquid membrane curing compound for use on pavement, curb and gutter, sidewalk and driveways shall conform to one of the following types:
 - 1. A non-pigmented, two component water insensitive epoxy having a solid epoxy content of 40 to 60 percent. The application rate is 5 to 8 mils wet.
 - 2. A liquid system of styrene acrylate Type I – Class 2 or liquid chlorinated rubber Type II – Class 2, complying with Federal Specification No. TT-C-800A. The application rate shall be 6 to 10 mils wet.
 - 3. A fan pattern spray nozzle shall be used when applying liquid curing membrane.

2.6 RELATED MATERIALS

- A. Traffic Paint: Alkyd-resin ready-mixed, complying with AASHTO M 248, Type N.
 - 1. Color: White.
 - 2. Color: Yellow.
 - 3. Color: Blue

2.7 JOINT MATERIALS

- A. Expansion Joint Materials:
 - 1. Expansion Material: Preformed, one-piece, non-extruding material.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) “Bondex” No. 941, or “Rubatex”; Rubatex Co., or “Homex”; Homasote Co.
 - 2. Joint Sealer: One component, gun-grade, moisture cured epoxy or urethane.
 - a. Products: Subject to compliance with requirements, provide one of the following:
 - 1) “Vulkem 45”; Mameco International Inc.
 - 2) “Sikaflex-1a”; Sika Chemical Corp.
 - 3) “Pecora GC-9”; Pecora Co.

2.8 CONCRETE MIXES

- A. Portland cement concrete used in construction of concrete pavement shall conform to MCIB Mix No. WA658-1-2-0.365 or WA561-1-2-0.410.
- B. Portland cement concrete used in construction of concrete curb and gutter shall conform to MCIB Mix No. WA610-1-4-0.410.

2.9 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

- A. Verify that the subgrade has been cut filled and compacted as required to achieve the lines, grades and cross sections shown on the plans within a tolerance of 1/4 inch from plan elevation.
- B. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Do not begin paving work until such conditions have been corrected and are ready to receive paving. Verify that the top six (6) inches of subgrade is compacted to 95 percent of maximum density per ASTM D-698.
- C. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement.
- B. Check completed formwork and screeds for grade and alignment to following tolerances:
 - 1. Top of Forms: Not more than 1/8 inch in 10 feet.
 - 2. Vertical Face on Longitudinal Axis: Not more than 1/4 inch in 10 feet.
- C. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

3.3 PLACING REINFORCEMENT

- A. Place reinforcement as indicated in the details and typical sections in the plans.

- B. Interrupt reinforcement at expansion joints.
- C. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- D. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.

3.4 PAVEMENT JOINTS

- A. General: Construct contraction, construction, and isolation joints true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to the centerline, unless indicated otherwise.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints, unless indicated otherwise.
- B. Contraction Joints: Provide weakened-plane contraction joints, sectioning concrete into areas as shown on Drawings. Construct contraction joints for a depth equal to at least 1/4 of the concrete thickness, to be completed within 12 hours after pour, as follows:
 - 1. Tooled Joints: Form contraction joints in fresh concrete by grooving and finishing each edge of joint with a radiused jointer tool.
 - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch-wide joints into hardened concrete when cutting action will not tear, abrade, or otherwise damage surface and before development of random contraction cracks.
 - 3. Contraction joints in street pavement shall be sawed joints.
 - 4. Installation of joint fillers and sealants is specified in Division 7, Section 07905 Paving Joint Sealants.
- C. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than 1/2 hour, unless paving terminates at isolation joints.
 - 1. Provide preformed galvanized steel or plastic keyway-section forms or bulkhead forms with keys, unless indicated otherwise. Embed keys at least 1-1/2 inches into concrete.
 - 2. Continue reinforcement across construction joints unless indicated otherwise. Do not continue reinforcement through sides of strip paving unless indicated.
 - 3. Provide tie bars at sides of paving strips where indicated.
 - 4. Use bonding agent on existing concrete surfaces that will be joined with fresh concrete.
 - 5. Installation of joint fillers and sealants is specified in Division 7, Section 07905 Paving Joint Sealants.
- D. Isolation Joints: Form isolation joints of preformed joint filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of 30 feet, unless indicated otherwise.

2. Extend joint fillers full width and depth of joint, not less than 1/2 inch or more than 1 inch below finished surface where joint sealant is indicated. Place top of joint filler flush with finished concrete surface when no joint sealant is required.
 3. Furnish joint fillers in one-piece lengths for full width being placed wherever possible. Where more than one length is required, lace or clip joint filler sections together.
 4. Protect top edge of joint filler during concrete placement with a metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
 5. Installation of joint fillers and sealants is specified in Division 7, Section 07905 Paving Joint Sealants.
- E. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one half of dowel length to prevent concrete bonding to one side of joint.

3.5 CURB JOINTS

- A. Joints shall be formed at right angles to the alignment of the curb as specified in the details on the plans
- B. Expansion joints shall be placed at all radius points, driveways, curb inlets and any additional locations directed by the Engineer.
- C. Expansion joints shall be formed using a one piece; 3/4-inch-thick preformed joint filler cut to the configuration of the curb section.
- D. Expansion joint material shall be secured to prevent any displacement during concrete placement, consolidation and finishing.
- E. Joint edges shall be rounded with a 1/4-inch radius edging tool.
- F. Curbs shall have one-inch-deep contraction joints at intervals of not less than 10 feet and not greater than 20 feet. The contraction joints shall extend across the entire curb section to one inch below the pavement surface and may be formed by one of the following methods.
- G. Contraction joints may be formed using a 1/8-inch metal template cut to the configuration of the curb section. Secure templates in place to prevent them from being disturbed. The templates shall remain in place until the concrete has attained its initial set and finishing is completed.
- H. Contraction joints may be tooled to the specified depth. All exposed joint edges shall be given a 1/4-inch radius.
- I. Sawed contraction joints may be cut when a curb machine has been used. Joints must be sawed within 24 hours of curb placement.
- J. Joint sealer is not required for contraction joints.

3.6 SIDEWALK AND DRIVEWAY JOINTS

- A. Joints shall be formed at right angles to the alignment of the sidewalk and driveway according to the details in the plans.
- B. Sidewalks shall have traverse joints spaced at a distance equal to the sidewalk width. Sidewalks greater than 6 feet in width shall be divided by longitudinal joints spaced not less than 30 inches or greater than 48 inches with the traverse joints at the same spacing to form a square pattern.
- C. Driveways wider than 20 feet shall have a traverse joint in the center.
- D. Expansion joints shall be located as indication in the details.
- E. Expansion joints shall be formed using a one piece; 1/2-inch-thick preformed joint filler cut to match the cross section of the sidewalk or driveway. The joint material shall be left 1/2 inch below the pavement surface or a tear strip provided to allow for application of joint sealer.
- F. Secure joint material to prevent any displacement during concrete placement, consolidation and finishing.
- G. Round joint edges with a 1/4-inch radius edging tool.
- H. Contraction joints for sidewalks and driveways shall be one inch deep and 1/8 inch wide with edges rounded by a 1/4-inch radius edging tool. The edger marks shall be left on all sidewalks and driveways.
- I. Contraction joints may be sawed with the approval of the Engineer.
- J. Joint sealer is not required for contraction joints.

3.7 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcing before placing concrete. Do not place concrete on surfaces that are muddy or frozen.
- C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.
- D. Comply with requirements and with APWA Section 2200 for measuring, mixing, transporting, and placing concrete.
- E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
 - 1. When concrete placing is interrupted for more than 1/2 hour, place a construction joint.

- F. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete complying with APWA Section 2200.
 - 1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcing, dowels, and joint devices.
- H. Screed paved surfaces with a straightedge and strike off. Use bull floats or darbies to form a smooth surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces prior to beginning finishing operations.
- I. Curbs and Gutters: When automatic machine placement is used, produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not acceptable, remove and replace with formed concrete.
- J. Slip-Form Pavers: When automatic machine placement is used for paving, produce paving to required thickness, lines, grades, finish, and jointing as required for formed paving.
 - 1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.
- K. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
- L. Cold-Weather Placement: Comply with provisions of MCIB Section 4 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. When air temperature has fallen to or is expected to fall below 40 deg F (4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.
- M. Hot-Weather Placement: Place concrete complying with MCIB Section 4 and as specified when hot weather conditions exist.
 - 1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 90 deg F (32 deg C). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.

2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.8 CONCRETE FINISHING

- A. Float Finish: Begin floating when bleed water sheen has disappeared, and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand-floating if area is small or inaccessible to power units. Finish surfaces to true planes within a tolerance of 1/4 inch in 10 feet as determined by a 10-foot-long straightedge placed anywhere on the surface in any direction. Cut down high spots and fill low spots. Refloat surface immediately to a uniform granular texture. Do not use wood floats.
 1. Sidewalks and Ramps:
 - a. Medium Broom Finish: Draw a stiff broom or other approved method across concrete surface perpendicular to line of traffic to produce an even, gritty texture.
 2. Roadways and Driveways:
 - a. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating surface 1/16 inch to 1/8 inch deep with a stiff-bristled broom, perpendicular to line of traffic.
- B. Final Tooling: Tool edges of paving, gutters, curbs, and joints formed in fresh concrete with a jointing tool to the following radius. Repeat tooling of edges and joints after applying surface finishes. Eliminate tool marks on concrete surfaces.
 1. Radius: 1/4 inch.
- C. Nonslip Aggregate Finish: Apply exposed aggregate finish to curb cuts.

3.9 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with the recommendations of MCIB Section 4 for cold weather and for hot weather protection during curing.
- B. Evaporation Control: In hot, dry, and windy weather, protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instructions after screeding and bull floating, but before floating.
- C. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

- D. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or a combination of these as follows:
 - 1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Recoat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.10 TRAFFIC PAINT

- A. Cleaning: Sweep and clean surface to eliminate loose material and dust.
- B. Striping: Use alkyd resin type traffic lane-marking paint, factory-mixed, quick-drying, and non-bleeding.
- C. Do not apply traffic and lane marking paint until layout and placement have been verified with Owner's Representative.
- D. Traffic Paint: Apply traffic paint for striping and other markings with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates to provide a 15-mil minimum wet film thickness.

3.11 FIELD QUALITY CONTROL TESTING

- A. The Owner will employ a qualified testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement. Sampling and testing for quality control may include the following:
 - 1. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 - a. Slump: ASTM C 143; one test at point of placement for each compressive-strength test but no less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
 - b. Air Content: ASTM C 231, pressure method; one test for each compressive-strength test but no less than one test for each day's pour of each type of air-entrained concrete.
 - c. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
 - d. Compression Test Specimens: ASTM C 31; one set of four standard cylinders for each compressive-strength test, unless directed otherwise. Mold and store cylinders for laboratory-cured test specimens except when field-cured test specimens are required.
 - e. Compressive-Strength Tests: ASTM C 39; one set for each day's pour of each concrete class exceeding 5 cu. yd. but less than 25 cu. yd., plus one set for each additional 50 cu. yd. Test one specimen at 7 days, test two specimens at 28 days, and retain one specimen in reserve for later testing if required.

2. When frequency of testing will provide fewer than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.
- B. Test results will be reported in writing to Owner or his Representative, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive strength tests shall contain the Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in paving, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7-day and 28-day tests.
- C. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as the sole basis for acceptance or rejection.
- D. Additional Tests: The testing agency will make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by the Owner or his Representative. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

3.12 REPAIRS AND PROTECTION

- A. Remove to the nearest joint and replace concrete paving that is broken, damaged, or defective, or does not meet the requirements of this Section.
- B. Drill test cores where directed by Owner or his Representative when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to paving with epoxy adhesive.
- C. Protect concrete from damage until accepted by the Owner. Exclude traffic from paving until it has achieved 70 percent of the 28-day compressive design strength. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep concrete paving not more than 2 days prior to date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 321373 - CONCRETE PAVEMENT JOINT SEALANTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Sealing control and expansion joints in concrete sidewalks, parking lots, and driveways.

1.2 WORK INCLUDED

- A. Work under this section includes providing all labor, material, and equipment to seal the contraction, control, and expansion joints in concrete sidewalk, parking lot, and driveway pavements.

PART 2 - PRODUCTS

2.1 EXPANSION JOINT MATERIAL

- A. Expansion joint material shall be 1/2" thick, full depth, pre-molded non-bituminous joint material, with the top 1/2" perforated for removal prior to sealing operations.

2.2 JOINT FILLER

- A. One or two component polysulfide polymer sealant or a one or two component polyurethane prepolymer sealant.
- B. Color: Gray.

2.3 BACKER ROD

- A. Closed cell polyethafoam sealant backer rod. Sized as required.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Control joints are to be sawed in accordance with the drawings and specifications.
- B. Seal joints following the sawing operation or as soon as possible thereafter.

3.2 GENERAL

- A. Manufacturer's recommendations on the joint sealer shall be strictly adhered to with the following additions:
 - 1. Joint sealant shall be left approximately 1/16" below the pavement surface level to prevent tracking.
 - 2. Sprinkle fine silica sand, as needed, to reduce tracking of the joint sealer.
- B. Pedestrian traffic shall be maintained as follows on sidewalks unless closure is authorized by the Owner's Representative. In no case will tracking of the joint material be tolerated.
 - 1. The Contractor may close off one-half the sidewalk width to pedestrian traffic while sealant cures.
 - 2. Contractor may place a board, notched on the bottom side with the notch centered over the joint and held securely in place with sandbags.

3.3 INSTALLATION

- A. Remove the perforated portion of the expansion joint material prior to placing the joint sealant.
- B. Clean all loose material from the joints with compressed air.
- C. In contraction joints, place a polyethafoam sealant backer rod of 5/16" to 3/8" below the surface elevation of the sidewalk. The backer rod must be uniformly installed depth-wise.
- D. Install expansion and construction joint sealant to approximately 1/16" below the sidewalk surface level.

END OF SECTION 321373

SECTION 323113 - CHAIN LINK FENCES AND GATES

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. Chain-link fences and gates. Galvanized and black PVC coated as noted on plans.
 - 2. Panic exit hardware and gate infill.

- B. Related Sections:

- 1. Section 033000 "Cast-in-Place Concrete" for post footings.
 - 2. Section 323130 "Chain Link Cantilever Slide Gates".

1.3 PERFORMANCE REQUIREMENTS

- A. Design chain-link fences and gates using performance requirements and design criteria indicated.

- B. Structural Performance: Perimeter fencing and framework shall withstand effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:

- 1. Minimum Post Size and Maximum Spacing for Wind Velocity Pressure: Determine based on mesh size and pattern specified, and on the specified minimum design wind pressures and according to CLFMI WLG 2445:
 - a. Wind Speed: per ASCE-7(05); 90mph (3 second gust).
 - b. Perimeter Fencing: Height: 8-feet (2.44 m) or as noted on plans.
 - c. Line Post Group: IA, ASTM F 1043, Schedule 40 steel pipe.
 - d. Wind Exposure Category: C.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.

1. Fence and gate posts, rails, and fittings.
 2. Chain-link fabric, reinforcements, and attachments.
 3. Gates and hardware.
- B. Shop Drawings: For gates and guardrails include plans, elevations, sections, details, hardware, and panic hardware with special fence infills to prevent unauthorized entry, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
- C. Samples for Initial Selection: For components with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of chain-link fence, and gates, from manufacturer.
- B. Product Test Reports: For framing strength according to ASTM F 1043.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
 1. Finishes.
 2. Gate hardware.
- B. Mockups: Build mockups to set quality standards for fabrication and installation.
 1. Include 10-foot (3 m) length of fence and gate which may become part of the completed work once approved.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
 1. Failures include, but are not limited to, the following:

- a. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - b. Fence settling, breakage, connection and material failure.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckled (top and bottom). Comply with CLFMI Product Manual and with requirements indicated below:
 1. Fabric Height: As indicated on Drawings.
 2. Steel Wire Fabric: Extruded wire for 9-gauge fence fabric.
 - a. Mesh Size: 2 inches (50 mm) (typical fencing).
 - b. Polymer-Coated Fabric: ASTM F 668, Fused Class 2B over zinc or Zn-5-Al-MM-alloy-coated steel wire.
 - 1) Color:
 - a) Black, complying with ASTM F 934, as noted on drawings.
 - b) Galvanized, as noted on drawings.
 - c. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
 3. Selvage: Knuckled at both selvages.

2.2 FENCE FRAMING

- A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 based on the following:
 1. Fence Heights: 8-feet in locations noted on Drawings.
 2. Connections: Provide friction fittings and clamps per manufacturer's recommendations for all fence framing members.
 3. Light Industrial Strength: Material Group IC-L, round steel pipe, electric-resistance-welded pipe.
 - a. Line Post: 2.875 inches (73 mm) in diameter.
 - b. End, Corner and Pull Post: 2.875 inches (73 mm).

4. Horizontal Framework Members: Top rail, intermediate and bottom rails on backstop only. Fences 8 feet and less to have top rail and bottom tension wire with corner bracing as required.
 - a. Top Rail: 1.66 inches (42 mm) in diameter.
5. Brace Rails: Comply with ASTM F 1043.
6. Metallic Coating for Steel Framing:
 - a. Type A, consisting of not less than 1.2 oz. per square foot minimum average zinc coating per ASTM A 123/A 123M.
 - b. Polymer-Coated Posts and Rails: ASTM F 668, Fused Class 2B over zinc or Zn-5-Al-MM-alloy-coated steel wire.

2.3 TENSION WIRE

- A. Tension Steel Wire: 0.148-inch- (3.8-mm-) diameter, tension wire complying with ASTM F 1664, Class 2B over zinc or Zn-5-Al-MM-alloy-coated steel wire.

2.4 SWING GATES

- A. General: Comply with ASTM F 900 for gate posts and single or double swing gate types.
 1. Gate Leaf Width: 36 inches (914 mm).
 2. Gate Fabric Height: 72 inches (1830 mm) or as noted on Drawings.
- B. Pipe and Tubing:
 1. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective galvanized coating finish matching fence framing.
 2. Gate Posts: Round tubular steel.
 3. Gate Frames and Bracing: Round tubular steel.
- C. Frame Corner Construction: Fencing shall be assembled with corner fittings.
- D. Hardware:
 1. Hinges: Cox-type hinge for 180-degree swing.
 2. Latches: Strong-arm type latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
 3. Gate Stops: Provide gate stop posts and self-latching device for hold open condition.

2.5 FITTINGS

- A. General: Comply with ASTM F 626.
- B. Post Caps: Provide for each post.

1. Provide line post caps with loop or fitting to receive top rail per Drawings.
- C. Rail and Brace Ends: For each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
 1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches (152 mm) long.
- E. Tension and Brace Bands: Pressed steel or aluminum alloy 6063.
- F. Tension Bars: Steel, length not less than 2 inches (50 mm) shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading or Mill-finished aluminum rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: Galvanized steel according to ASTM F 626.
 1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
 - a. Aluminum: ASTM B 211 (ASTM B 211M); Alloy 1350-H19; 0.148-inch- (3.76-mm-) diameter, mill-finished wire.
 - b. Finish to match fence fabric.
- I. Finish:
 1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g/sq. m) Zinc.
 2. Finish to match fence fabric.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 m) or line of sight between stakes. Indicate locations of utilities, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION, GENERAL

- A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.
 - 1. Install fence fabric on outside of fence framework.

3.4 CHAIN-LINK FENCE INSTALLATION

- A. Post Excavation: Drill or hand-excavate holes for posts to footing diameters and spacing indicated, in firm, undisturbed soil.
- B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Top of Fence Footing: Top of footing shall match finish grade and slope away from the post or install a minimum of 6 inches below grade to accommodate the concrete mow strips, if applicable.
- C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 30 degrees or more.
- D. Line Posts: Space line posts uniformly at 10 feet (3 m) o.c.
- E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
 - 1. Locate horizontal braces at mid-height of fabric 72 inches (1830 mm) or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-mm-) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 mm) on center. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:

1. Extended along bottom of fence fabric. Install bottom tension wire within 6 inches (152 mm) of bottom of fabric and tie to each post with not less than same diameter and type of wire.
- G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- H. Chain-Link Fabric: Apply fabric to inside of enclosing framework. Leave 1-inch (25 mm) between top of maintenance strip and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- I. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches (380 mm) o.c.
- J. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
 1. Maximum Spacing: Tie fabric to line posts at 12 inches (300 mm) o.c. and to braces at 24 inches (610 mm) o.c.
- K. Fasteners: Install nuts tight and secure by mechanical means for tension bands and carriage bolts opposite the playing field side of the fence.
- L. Backstops: Provide framework fittings.

3.5 GATE INSTALLATION

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.6 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Lubricate hardware and other moving parts.

END OF SECTION 323113

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SECTION 323113 - CHAIN LINK CANTILEVER SLIDE GATES

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. Cantilever slide gates.

- B. Related Sections:

- 1. Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete post footings.
 - 2. Section 312000 "Earth Moving" for site excavation and backfill.
 - 3. Section 323113 "Chain Link Fences and Gates."

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Heavy-duty cantilever chain-link slide gate posts and framework shall withstand effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:

- 1. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified and on the following:
 - a. Wind Loads: 90 mph.
 - b. Exposure Category: B.
 - c. Gate Height: 8-feet; and matching existing fencing heights as noted on the Drawings.
 - d. Gate Posts: Provide gate post diameter and footing design to accommodate the minimum slide gate leaf width as shown on the Drawings.
 - e. Material Group: IA, ASTM F 1043, Schedule 40 steel pipe.

1.4 SUBMITTALS

- A. Product Data: Provide manufacturer's catalog cuts with printed specifications and installation instructions. Provide operation and maintenance data covering the installed products.
- B. Shop Drawings: Include delegated design plans, elevations, sections, footings, details, and attachments to other work. Show accessories, hardware, gate operation, and operational

clearances. Comply with live and dead loads as shown on the Drawings and provide professionally sealed Drawings by an engineer in the state of Missouri.

- C. Qualification Data: For qualified professional engineer and factory-authorized service representative.
- D. Product Certificates: For each type of chain-link fence and gate from manufacturer.
- E. Product Test Reports: For framing strength according to ASTM F 1043.
- F. Warranty: Sample of special warranty.
- G. Operation and Maintenance Data.
- H. Certification of Performance Criteria:
 - 1. Manufacturer of gate system shall provide certification stating the gate system includes the following material components that provide superior performance and longevity. Alternate designs built to minimum standards that do not include these additional structural features shall not be accepted.
 - 2. Gate track system shall be keyed to interlock into gate frame member (providing 200% additional strength when compared to weld only keyless systems). When interlocked with and welded to the "keyed" frame top member, gate track forms a composite structure.
 - 3. Gate shall have a minimum counterbalance length of 50% opening width which provides a 36% increase in lateral resistance (when compared to ASTM minimum of 40% counterbalance). Provide counterbalance section shall be filled with fabric or other specified material for automated gate system.
 - 4. To provide superior structural integrity, intermediate vertical members shall be used - with spacing between verticals to be less than 50% of the gate frame height.
 - 5. Entire gate frame (including counterbalance section) shall include 2 adjustable stainless or galvanized steel cables (minimum 3/16 inch) per bay to allow complete gate frame adjustment (maintaining strongest structural square and level orientation).
 - 6. Gate truck assemblies shall be tested for continuous duty and shall have precision ground and hardened components. Bearings shall be pre-lubricated and contain shock resistant outer races and captured seals.
 - 7. Gate truck assemblies shall be supported by a minimum 5/8-inch plated steel bolt with self-aligning capability, rated to support a 2,000 # reaction load.
 - 8. Hanger brackets shall be hot dipped galvanized steel with a minimum 3/8-inch thickness that is also gusseted for additional strength.
 - 9. Gate top track and supporting hangar bracket assemblies shall be certified by a licensed professional engineer to withstand a 2,000 lb. vertical reaction load without exceeding allowable stresses.

1.5 PROJECT CONDITIONS

- A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements provide Tymetal Corporation; Fortress Heavy-Duty Cantilever Slide Gate and operator system or approved equal.
- B. Substitutions: All other systems must be submitted to the Architect in accordance with Section 012500 "Substitution Procedures" prior to the bid date. Products submitted must meet performance criteria.
- C. Gate manufacturer shall certify gate is manufactured in compliance with ASTM F 2200, Standard Specification for Automated Vehicular Gate Construction.
- D. Gate manufacturer shall provide independent certification as to the use of a documented Welding Procedure Specification and Procedure Qualification Record to insure conformance to the AWS D1.2 welding code. Upon request, Individual Certificates of Welder Qualification documenting successful completion of the requirements of the AWS D1.2 code shall also be provided.

2.2 CANTILEVER SLIDE GATE MATERIALS

- A. Gate Frame: The gate frame shall be fabricated from 6063-T6 aluminum alloy extrusions. The top member shall be a 3-inch by 5-inch (76mm by 127mm) aluminum structural channel/tube extrusion weighing not less than 3.0 lb./lf (4.4kg/m). To maintain structural integrity this frame member shall be keyed to interlock with the keyed track member. If fabricated as a single horizontal piece, the bottom member shall be a 2-inch by 5-inch (51 mm by 127 mm) aluminum structural tube weighing not less than 2.0 lb./lf (2.9kg/m). If fabricated in two horizontal pieces, the bottom member shall be a 5-inch (127 mm) aluminum structural channel weighing not less than 2.6 lb./lf (3.8kg/m).

- B. Vertical Members and Chain Link Infill: The vertical members at the ends of the gate frame shall be P shaped in cross section with a nominal base dimension of no less than 2 inches by 2 inches (51 mm by 51 mm) and weighing not less than 1.6 lb./lf (2.3kg/m).
 - 1. Major 2-inch by 2-inch (51mm by 51mm) vertical members weighing not less than 1.1 lb./lf shall separate each bay and shall be spaced at less than gate height intervals.
 - 2. Intermediate 1-inch by 2-inch (25mm by 51mm) vertical members weighing not less than .82 lb./lf shall alternate between 2-inch by 2-inch major members.
- C. Gate Track: The gate frame shall have a separate semi-enclosed keyed track, extruded from 6005A-T61 or 6105-T5 aluminum alloy, weighing not less than 2.9 lb./lf (4.2kg/m). The track member is to be located on only one side of the top primary. Welds to be placed alternately along the top and side of the track at 9-inch (229mm) centers with welds being a minimum of 2 inches (51mm).
- D. Gate Mounting:
 - 1. The gate frame is to be supported from the track by two (2) swivel type, self-aligning, 4-wheeled, sealed lubricant, ball-bearing truck assemblies.
 - 2. The bottom of each support post shall have a bracket equipped with a pair of 3-inch (76mm) UHMW guide wheels. Wheel cover protectors shall be included with bottom guides to comply with UL325.
 - 3. Gap protectors shall be provided and installed, compliant with ASTM F 2200-05.
- E. Diagonal Bracing:
 - 1. Diagonal X bracing of 3/16-inch or 1/4-inch diameter stainless or galvanized steel cable shall be installed throughout the entire gate frame.
 - 2. Chain Link: 2-inch by 2-inch by 9 gauge aluminized steel chain link fabric shall extend the entire length of the gate (if operated gate, counterbalance must also have fabric to prevent reach through and comply with ASTM F2200) Fabric shall be attached at each end of the gate frame by standard fence industry tension bars and tied at each 2-inch by 2-inch (51mm x 51mm) vertical member with standard fence industry ties. ASTM F2200 requires attachment method that leaves no leading or bottom edge protrusions cannot exceed 0.5 inch.

2.3 POSTS

- A. A single set of support posts shall be minimum 4-inch O.D. (102mm) round SS40 or 4-inch by 4-inch by 3/16-inch wall square steel tubing, grade 500. Gate posts shall be galvanized or coated and supported in concrete footings per delegated design and per the Drawings.

2.4 FINISH

- A. Gates to be hot-dipped galvanized or black vinyl coated PVC to match chain link fencing as noted on plans.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 - 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GATE INSTALLATION

- A. The gate and installation shall conform to ASTM F 1184 standards for aluminum cantilever slide gates, Type II, Class 2.
- B. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.3 ADJUSTING

- A. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
- B. Lubricate hardware and other moving parts.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain chain-link fences and gates.
- B. The complete system shall be adjusted to assure it is performing properly.

END OF SECTION 323113

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SECTION 323300 - SITE FURNISHINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Steel pipe bollards in concrete footings.

- B. Related Requirements:

- 1. Section 033000 "Cast-in-Place Concrete" for installation of pipe sleeves cast or formed voids in concrete footings and concrete fill in pipe bollards.
 - 2. Section 312000 "Earth Moving" for excavation for installing concrete footings.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples for Initial Selection: For units with factory-applied finishes.
- C. Maintenance Data: For all site furnishings to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 STEEL PIPE BOLLARDS

- A. Bollard Construction:

- 1. Pipe OD: Not less than 6.5" diameter.
 - a. Steel: Schedule 40 pipe.
 - 2. Style: Dome top.
 - 3. Overall Height: As indicated on the Drawings.
 - 4. Installation Method: Cast in concrete footing with concrete fill inside the pipe.

- B. Steel Finish: Hot dipped galvanized with paint finish.

1. Paint Color: "Yellow", high performance paint and primer system with color as selected by Architect from manufacturer's full range.

2.2 MATERIALS

- A. Steel and Iron: Free of surface blemishes and complying with the following:
 1. Plates, Shapes, and Bars: ASTM A36/A36M.
 2. Steel Pipe: Standard-weight steel pipe complying with ASTM A53/A53M, or electric-resistance-welded pipe complying with ASTM A135/A135M.
 3. Tubing: Cold-formed steel tubing complying with ASTM A500/A500M.
 4. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A513/A513M, or steel tubing fabricated from steel complying with ASTM A1011/A1011M and complying with dimensional tolerances in ASTM A500/A500M; zinc coated internally and externally.
 5. Sheet: Commercial steel sheet complying with ASTM A1011/A1011M.
- B. Galvanized Steel: Hot dipped with high performance paint system or powder coat finish and complying with the following:
 1. Pipe: Schedule 40 steel pipe complying with ASTM A312/A312M.
 2. Tubing: ASTM A554.
- C. Anchors, Fasteners, Fittings, and Hardware: Stainless steel or Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials; commercial quality, tamperproof, vandal and theft resistant, concealed, recessed, and capped or plugged.
- D. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M; recommended in writing by manufacturer, for exterior applications.
- E. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.
- F. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
 1. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. (0.27 kg/sq. m) of zinc after welding, a chromate conversion coating, and a clear, polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than 0.3 mil (0.0076 mm) thick.
 2. Hot-Dip Galvanizing: According to ASTM A123/A123M, ASTM A153/A153M, or ASTM A924/A924M.

2.3 FABRICATION

- A. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
- B. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended, so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
- C. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
- D. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.
- E. Factory Assembly: Factory assemble components to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.

2.4 GENERAL FINISH REQUIREMENTS

- A. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.5 STEEL AND GALVANIZED-STEEL FINISHES

- A. Powder-Coat Finish: Manufacturer's standard polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for correct and level finished grade, mounting surfaces, installation tolerances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
- B. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
- C. Install site furnishings level, plumb, true, and securely anchored at locations indicated on Drawings.
- D. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.

END OF SECTION 323300

SECTION 329200 - TURF AND GRASSES

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. Seeding.
 - 2. Sodding.
 - 3. Hydro-mulching.
 - 4. Erosion-control material(s).

- B. Related Sections:

- 1. Section 311000 "Site Clearing" for topsoil stripping and stockpiling.
 - 2. Section 312000 "Earthwork" for excavation, filling and backfilling, and rough grading.
 - 3. Section 329300 "Plants" for border edgings.

1.3 DEFINITIONS

- A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- E. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- F. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.

- G. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- H. Subsoil: All soil beneath the topsoil layer of the soil profile and typified by the lack of organic matter and soil organisms.
- I. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Pesticides and Herbicides: Include product label and manufacturer's application instructions specific to this Project.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of the supplier.
- C. Qualification Data: For qualified landscape Installer.
- D. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- E. Material Test Reports: For existing native surface topsoil and imported or manufactured topsoil.
- F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment from seed.
 - 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 2. Experience: Five years' experience in turf installation in addition to requirements in Division 01 Section "Quality Requirements."
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

4. Personnel Certifications: Installer's field supervisor shall have certification in all of the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician - Exterior, with installation maintenance irrigation specialty area(s), designated CLT-Exterior.
 - b. Certified Turfgrass Professional, designated CTP.
 - c. Certified Turfgrass Professional of Cool and Warm Season Lawns, designated CTP-CSL.
 5. Maintenance Proximity: Not more than three hours' normal travel time from Installer's place of business to Project site.
 6. Pesticide Applicator: State licensed, commercial.
- B. Soil-Testing Laboratory Qualifications: An independent laboratory or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- C. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; sodium absorption ratio; deleterious material; pH; and mineral and plant-nutrient content of the soil.
1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
 2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Architect. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
 3. Report suitability of tested soil for turf growth.
 - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. (92.9 sq. m) or volume per cu. yd. (0.76 cu. m) for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.
- D. Pre-installation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

- B. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.
- C. Bulk Materials:
 - 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 - 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 - 3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

1.7 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Spring Seed Planting: March 15th to May 15th.
 - 2. Fall Seed Planting: August 15th to October 30th.
 - 3. Wetland Seed Planting: April 15th to July 15th.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.8 MAINTENANCE SERVICE

- A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
 - 1. Seeded Turf: 60 days from date of Substantial Completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
 - 2. Sodded Turf: 60 days from date of Substantial Completion.
- B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

1.9 WARRANTY FOR PERMANENT SEED

- A. Special Warranty: Installer agrees to repair or replace lawn and/or wetland meadow areas that have not resulted in a good stand, firmly rooted, uniform in color and quality, and reasonably free of weeds, diseases, erosion, or other visible imperfections.
 - 1. Warranty period: One (1) year beginning at the end of Contractor's maintenance period.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: State-certified seed of grass species as follows:
- C. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Tall Turf-Type Fescue blend; drought tolerant varieties performing well in local NTEP trials, including:
 - a. 80 percent Tall Turf-Type Fescue (*Festuca arundinacea*).
 - b. 10 percent Kentucky Bluegrass (*Poa pratensis*).
 - c. 10 percent annual Ryegrass (*Lolium multiflorum*).

2.2 TURFGRASS SOD

- A. Turfgrass Sod: Certified, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
- B. Sod Netting: Netted sod will not be accepted. If sod is delivered to the site with netting, Contractor shall remove the netting and properly dispose of prior to installation of turf sod.
- C. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Site Areas: Tall turf type fescue blend, a minimum of three cultivars selected for drought tolerance and having performed well in local NTEP turf trials, including:
 - a. 80 percent tall turf type Fescue blend (*Festuca arundinacea*).
 - b. 10 percent Kentucky Bluegrass 'Touchdown' (*Poa pratensis*).

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: T, with a minimum of 99 percent passing through No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through No. 60 (0.25-mm) sieve.
- B. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- C. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 (0.30-mm) sieve.
- D. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

2.4 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

2.5 FERTILIZERS

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 10 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.6 PLANTING SOILS

- A. Planting Soil: Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process and stockpiled on-site. Verify suitability of native surface topsoil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
1. Supplement with another specified planting soil when quantities are insufficient.
 2. Mix existing, native surface topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Mix Ratio of Loose Compost to Topsoil by Volume: 1:4.
 - b. Weight of Lime per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - c. Weight of Iron Sulfate per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - d. Weight of Agricultural Gypsum per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - e. Weight of Bonemeal per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - f. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - g. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
- B. Planting Soil: Imported topsoil or manufactured topsoil from off-site sources. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from agricultural land, bogs or marshes.
1. Additional Properties of Imported Topsoil or Manufactured Topsoil: Screened and free of stones 1 inch (25 mm) or larger in any dimension; free of roots, plants, sod, clods, clay lumps, pockets of coarse sand, paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, building debris, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, acid, and other extraneous materials harmful to plant growth; free of obnoxious weeds and invasive plants including quackgrass, Johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel, and brome grass; not infested with nematodes, grubs, other pests, pest eggs, or other undesirable organisms and disease-causing plant pathogens; friable and with sufficient structure to give good tilth and aeration. Continuous, air-filled, pore-space content on a volume/volume basis shall be at least 15 percent when moisture is present at field capacity. Soil shall have a field capacity of at least 15 percent on a dry weight basis.
 2. Mix imported topsoil or manufactured topsoil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
 - a. Ratio of Loose Compost to Topsoil by Volume: 1:4.
 - b. Weight of Lime per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - c. Weight of Iron Sulfate per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - d. Weight of Agricultural Gypsum per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - e. Weight of Bonemeal per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - f. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.
 - g. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): Per soils analysis.

2.7 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- C. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- D. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

2.8 PESTICIDES

- A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

2.9 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydro-mulch overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

- A. Limit turf subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches (100 mm). Remove stones larger than 1 inch (25 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply superphosphate fertilizer directly to subgrade before loosening.
 - 2. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.

- b. Mix lime with dry soil before mixing fertilizer.
 - 3. Spread planting soil to a depth of 4 inches (100 mm) on all lawn areas, and planting areas. Apply a 6-inch (150 mm) depth on natural grass sports fields, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top 2 inches (50 mm) of subgrade. Spread remainder of planting soil.
 - b. Reduce elevation of planting soil to allow for soil thickness of sod.
 - C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of at least 6 inches (150 mm). Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches (100 mm) of soil. Till soil to a homogeneous mixture of fine texture.
 - a. Apply superphosphate fertilizer directly to surface soil before loosening.
 - 3. Remove stones larger than 1 inch (25 mm) in any dimension and sticks, roots, trash, and other extraneous matter.
 - 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
 - D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
 - E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
 - F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- 3.4 PREPARATION FOR EROSION-CONTROL MATERIALS
- A. Prepare area as specified in "Turf Area Preparation" Article.
 - B. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.
 - C. Fill cells of erosion-control mat with planting soil and compact before planting.

- D. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
- E. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

- A. Sow seed with a no-till drill type seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 10 to 12 lbs/1000 sq. ft.
- C. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
- D. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.
- E. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch (4.8 mm), and roll surface smooth.

3.6 HYDROMULCHING

- A. Hydromulching: Protect all newly turf grass and native wetland seeded areas with Hydromulch. Mix specified fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with nonasphaltic fiber-mulch manufacturer's recommended tackifier.
 - 2. Apply slurry uniformly to all seeded areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre (15.6-kg/92.9 sq. m) dry weight.
 - 3. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.

3.7 SODDING

- A. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.

- B. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
 - 1. Lay sod across angle of slopes exceeding 1:3.
 - 2. Anchor sod on slopes exceeding 1:6 with steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.
 - 3. Remove and dispose of sod netting prior to installing sod on sports fields and lawn areas.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches (38 mm) below sod.

3.8 TURF MAINTENANCE

- A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and re-mulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
- B. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches (100 mm).
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.
- C. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowing. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowing to maintain the following grass height:
 - 1. Mow tall turf type fescue to a height of 2-1/2 to 3 inches (63 to 75 mm) or less.
- D. Turf Post-fertilization: Apply fertilizer after initial mowing and when grass is dry.

1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) to turf area.

3.9 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 5 by 5 inches (125 by 125 mm).
 2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.10 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.11 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required protecting newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- C. Remove non-degradable erosion-control measures after grass establishment period.

END OF SECTION 329200

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SECTION 329300 - PLANTS

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. Plants.
 - 2. Trees.
 - 3. Shrubs.
 - 4. Tree stabilization.
 - 5. Soil amendments.
 - 6. Weed control barriers.

- B. Related Sections:

- 1. Section 312000 "Earthwork" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
 - 2. Section 329200 "Turf and Grasses" for turf (lawn) planting, wetland meadow planting, and erosion-control materials.

1.3 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
- C. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of plant required.
- D. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.

- E. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
- F. Finish Grade: Elevation of finished surface of planting soil.
- G. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- H. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
- I. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- J. Planting Area: Areas to be planted.
- K. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- L. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
- M. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
- N. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
- O. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
- P. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- Q. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated, including soils.
 - 1. Plant Materials: Include quantities, sizes, quality, and sources for plant materials.

- B. Samples for Verification: For each of the following:
1. Shredded Wood Mulch: 1-quart (1-liter) volume of each organic mulch required; in sealed plastic bags labeled with composition of materials by percentage of weight and source of mulch. Each Sample shall be typical of the lot of material to be furnished; provide an accurate representation of color, texture, and organic makeup.
 2. Edging Materials and Accessories: Manufacturer's standard size, to verify color finish selected.
- C. Qualification Data: For qualified landscape Installer. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses, and year completed, and include names and addresses of owners' contact persons.
- D. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
1. Manufacturer's certified analysis of standard products.
 2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
- E. Agronomic Soils Test: Provide agronomic soils testing of stockpiled or imported soils and provide recommendations for soil amendments.
- F. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before expiration of required periods.
- G. Planting Schedule: Indicating planting dates for exterior plants.
- H. Warranty: Sample of special warranty.
- I. Qualification Data: For qualified landscape Installer showing the installer's professional certifications as required. Include list of similar projects completed by Installer demonstrating Installer's capabilities and experience. Include project names, addresses and year completed and include names and addresses of owners' contact persons.
- J. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
1. Manufacturer's certified analysis of standard products.
 2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
- K. Material Test Reports: For imported or manufactured topsoil.
- L. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year. Submit before the start of required maintenance periods.
- M. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in the successful establishment of plants.
 - 1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
 - 2. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 Sections.
 - 3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 4. Personnel Certifications: Installer's field supervisor shall have certification in the following categories from the Professional Landcare Network:
 - a. Certified Landscape Technician – Exterior, with installation, maintenance, and irrigation specialty area(s), designated CLT-Exterior.
 - 5. Pesticide Applicator: State licensed, commercial.
- B. Topsoil Analysis: Contractor will engage a soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil. Contractor shall obtain a copy of the data from the Owner and shall comply with its requirements.
 - 1. Report suitability of tested soil for lawns and landscape plant material growth.
 - a. State recommendations in weight per 1000 sq. ft. (92.9 sq. m) or volume per cu. yd. (0.76 cu. m) for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.
- C. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
- D. Measurements: Measure according to ANSI Z60.1. Do not prune to obtain required sizes.
 - 1. Trees and Shrubs: Measure with branches and trunks or canes in their normal position. Take height measurements from or near the top of the root flare for field-grown stock and container grown stock. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip to tip. Take caliper measurements 6 inches (150 mm) above the root flare for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the root flare for larger sizes.
- E. Plant Material Observation: Architect may observe plant material either at place of growth or at site before planting for compliance with requirements for genus, species, variety, cultivar, size,

and quality. Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, pests, disease symptoms, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.

1. Notify Architect of sources of planting materials seven days in advance of delivery to site.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. Bulk Materials:
 1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Accompany each delivery of bulk fertilizers and soil amendments with appropriate certificates.
- C. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
- D. Handle planting stock by root ball.
- E. Deliver plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
 1. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
 2. Do not remove container-grown stock from containers before time of planting.
 3. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

1.7 PROJECT CONDITIONS

- A. Field Measurements: Verify actual grade elevations, service and utility locations, irrigation system components, and dimensions of planting and construction contiguous with new plantings by field measurements before proceeding with planting work.
- B. Interruption of Existing Services or Utilities: Do not interrupt services or utilities to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary services or utilities according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than two days in advance of proposed interruption of each service or utility.
 - 2. Do not proceed with interruption of services or utilities without Construction Manager's written permission.
- C. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 - 1. Spring Planting: March 1st May 15th.
 - 2. Fall Planting: August 15th to October 15th.
- D. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed according to manufacturer's written instructions and warranty requirements.
- E. Coordination (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas otherwise acceptable to the Architect.
 - 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.8 WARRANTY

- A. Special Warranty: Installer's standard form in which Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by Owner, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling or blowing over.
 - c. Faulty performance of tree stabilization and edgings.
 - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Periods from Date of Substantial Completion:

- a. Trees, Shrubs, Vines, and Ornamental Grasses: 24 months.
 - b. Ground Covers and Other Plants: 24 months.
3. Include the following remedial actions as a minimum:
- a. Immediately remove dead plants. Replace immediately, unless required to plant in the succeeding planting season.
 - b. Replace plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each plant will be required except for losses or replacements due to failure to comply with requirements.
 - d. Provide extended warranty for period equal to original warranty period, for replaced plant material.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service for Trees and Shrubs: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.
1. Maintenance Period: Three months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 TREE AND SHRUB MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
1. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than 3/4 inch (19 mm) in diameter; or with stem girdling roots will be rejected.
 2. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
- B. Provide plants of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of plants required. Plants of a larger size may be used if acceptable to Architect, with a proportionate increase in size of roots or balls.

- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- D. Labeling: Label at least one plant of each variety, size, and caliper with a securely attached, waterproof tag bearing legible designation of common name and full scientific name, including genus and species. Include nomenclature for hybrid, variety, or cultivar, if applicable for the plant as shown on Drawings.

2.2 SHADE AND FLOWERING TREES

- A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, or height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
 - 1. Provide balled and burlapped trees.
 - 2. Branching Height: One-half of tree height.
- B. Small Upright Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:
 - 1. Stem Form: Single trunk.
 - 2. Provide balled and burlapped trees.
- C. Small Spreading Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:
 - 1. Stem Form: Multi-stem.
 - 2. Provide balled and burlapped trees.

2.3 DECIDUOUS SHRUBS

- A. Form and Size: Shrubs with not less than the minimum number of canes required by an measured according to ANSI Z60.1 for type, shape, and height of shrub.
 - 1. Shrub sizes indicated are sizes after pruning.
 - 2. Provide balled and burlapped or container-grown shrubs.

2.4 CONIFEROUS EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.
- B. Form and Size: Specimen quality as described, symmetrically shaped coniferous evergreens.
 - 1. Shearing Designation: Semi-sheared or lightly sheared (LS).
 - 2. Provide balled and burlapped trees.

2.5 GROUND COVER PLANTS

- A. Ground Cover: Provide ground cover of species indicated, established and well rotted in pots or similar containers, and complying with ANSI Z60.1.

2.6 PLANTS

- A. Perennials and Grasses: Provide healthy, field-grown plants from a commercial nursery, of species and variety shown or listed, complying with requirements in ANSI Z60.1.

2.7 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: T, with a minimum of 99 percent passing through No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through No. 60 (0.25-mm) sieve.
- B. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
- C. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through No. 50 (0.30-mm) sieve.
- D. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

2.8 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 7.5; moisture content 35 to 55 percent by weight; 100 percent passing through 1/2-inch (13-mm) sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 50 to 60 percent of dry weight.
 - 2. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

2.9 FERTILIZERS

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 10 percent phosphoric acid.

- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
 - 2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
- D. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
 - 1. Size: 10-gram tablets.
 - 2. Nutrient Composition: 20 percent nitrogen. 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.
- E. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.
- F. Mycorrhizal Inoculant: Mycorrhizal inoculum (Endo/Ecto) capable of colonizing host plant roots.
 - 1. Product: Subject to compliance with requirements, provide Premier Tech Biotechnologies or "Myke Transplant Enhancer" or approved equal.

2.10 TOPSOIL

- A. ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 4 percent organic material content; free of stones 1 inch (25 mm) or larger in any dimension and other extraneous materials harmful to plant growth.
- B. Topsoil Source: Reuse existing, native surface topsoil stockpiled on-site. Clean soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
 - 1. Supplement with imported or manufactured topsoil from offsite sources when quantities are insufficient. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from agricultural land, bogs, or marshes.

2.11 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
 - 1. Type: Shredded Cypress or Cedar mulch.

2. Size Range: 3-inches maximum, 1/4-inch minimum.
3. Color: Natural.

2.12 WEED-CONTROL BARRIERS

- A. Granular, film forming, chemical weed barrier within organic mulch areas:
 1. Product: Subject to compliance with requirements, provide the following or approved equal:
 - a. Treflan.
- B. Non-woven Geotextile Filter Fabric: Install below rip-rap and aggregate mulch areas only. Polypropylene or polyester fabric 3 oz./sq. yd. (101 g/sqm) minimum. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis and acids.

2.13 TREE STABILIZATION MATERIALS

- A. Proprietary Staking-and-Guying Devices: Proprietary stake and adjustable tie systems to secure each new planting by plant stem; sized as indicated and per manufacturer's written recommendations.
 1. For up to 4-inch caliper trees. Includes, three polypropylene guy lines (3/4-inch by 12 feet (800 lb. test), olive color, UV resistant and (3) nickel plated spring cam-lock tension clips and (3) arrowhead nylon anchors with driver device.
 2. Products: Subject to compliance with requirements, provide the following or approved equal:
 - a. Arborbrace Tree Guying System; Model ATG-R.

2.14 PESTICIDES

- A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- B. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- C. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive plants for compliance with requirements and conditions affecting installation and performance.
 - 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 - 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 - 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 - 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
- B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.
- D. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.
- E. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

3.3 PLANTING AREA ESTABLISHMENT

- A. Loosen subgrade of planting areas to a minimum depth of 6 inches (150 mm). Remove stones larger than 1-1/2 inches (38 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply fertilizer directly to subgrade before loosening.

2. Spread planting soil to a depth of 6 inches (150 mm) but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top 4 inches (100 mm) of subgrade. Spread remainder of planting soil.
- B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.4 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
 1. Excavate approximately three times as wide as ball diameter for balled and burlapped stock.
- B. Subsoil and topsoil removed from excavations may be used as planting soil.
- C. Obstructions: Notify Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
 1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.
- D. Drainage: Notify Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
- E. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.5 TREE AND SHRUB PLANTING

- A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1.
- B. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare 2 inches (50 mm) above adjacent finish grades.
 1. Completely saturate and cover root ball with granular plant enhancer on entire root ball per manufacturer's recommendations.

2. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 3. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 4. Place slow-release planting tablets in each planting pit when pit is approximately three quarters filled. Install three tablets minimum per tree or per manufacturer's recommendations. Place tablets beside root ball about 1-inch from root tips. Do not place tablet in bottom of hole.
 5. Continue backfilling process. Water again after placing and tamping final layer of planting soil mix.
- C. Set container-grown stock plumb and in center of planting pit or trench with root flare 2 inches (50 mm) above adjacent finish grades.
1. Carefully remove root ball from container without damaging root ball or plant.
 2. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
 3. Place planting tablets in each planting pit when pit is approximately three- quarter filled. Install three tablets minimum per tree or per manufacturer's recommendations. Place tablets beside root ball about 1-inch from root tips. Do not place tablet in bottom of hole.
 4. Continue backfilling process. Water again after placing and tamping final layer of planting soil mix.
- D. Organic Mulching: Apply 3 inches (75 mm) average thickness of organic mulch extending 24 inches (600 mm) beyond edge of planting pit. Do not place mulch within 2 inches (50 mm) of trunks or stems for all trees/plants set individually within lawn areas.
- E. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.

3.6 TREE AND SHRUB PRUNING

- A. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

3.7 TREE STABILIZATION

- A. Install trunk stabilization as follows unless otherwise indicated:

1. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

3.8 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs and vines 12 inches (300 mm) apart or as indicated in even rows with triangular spacing.
- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. For rooted cutting plants supplied in flats, plant each in a matter that will minimally disturb the root system but to a depth not less than two nodes.
- E. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- F. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- G. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.9 PLANTING AREA MULCHING

- A. Organic Mulch Areas: Install chemical weed control barriers before installing organic mulch, place on soil and after mulching on top of finish mulch according to manufacturer's written instructions.
- B. Aggregate Rip-Rap Areas: Install filter fabric over compacted subgrade and fasten to subgrade with galvanized steel staples per manufacturer recommendations.

3.10 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
- B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.

3.11 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate

applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

- B. Pre-Emergent Herbicides (Selective and Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.
- C. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

3.12 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
- C. After installation and before Substantial Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

3.13 DISPOSAL

- A. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off Owner's property.

END OF SECTION 329300

SECTION 334100 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Channel drainage systems.
3. Manholes.
4. Cleanouts.
5. Nonpressure transition couplings.
6. Catch basins.
7. Stormwater inlets.
8. Pipe outlets.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Manholes: Include plans, elevations, sections, details, frames, and covers.
2. Catch basins and stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

B. Field quality-control reports.

1.4 PROJECT CONDITIONS

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

1. Notify Owner no fewer than three days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Owner's written permission.

PART 2 - PRODUCTS

2.1 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service class.
- B. Gaskets: ASTM C 564, rubber.
- C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Shielded Couplings:
 - 1. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 DUCTILE-IRON, CULVERT PIPE AND FITTINGS

- A. Pipe: ASTM A 716, for push-on joints.
- B. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
- C. Compact Fittings: AWWA C153, for push-on joints.
- D. Gaskets: AWWA C111, rubber.

2.4 PE PIPE AND FITTINGS

- A. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10: AASHTO M 252M, Type S, with smooth waterway for coupling joints.
 - 1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
 - 2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
- B. Corrugated PE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
 - 1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
 - 2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.5 PVC PIPE AND FITTINGS

A. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F 477, elastomeric seals.

2.6 CONCRETE PIPE AND FITTINGS

A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76.

1. Bell-and-spigot or tongue-and-groove ends and gasketed joints with ASTM C 443 rubber gaskets.
2. Class III, Wall B.

2.7 NONPRESSURE TRANSITION COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Concrete Pipes: ASTM C 443, rubber.
2. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
3. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. Description: Elastomeric sleeve with corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Shielded, Flexible Couplings:

1. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

E. Ring-Type, Flexible Couplings:

1. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.8 EXPANSION JOINTS

A. Ductile-Iron Flexible Expansion Joints:

1. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig minimum working pressure and for offset and expansion indicated.

2.9 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
2. Top-Loading Classification(s): Medium Duty.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

B. Plastic Cleanouts:

1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

2.10 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: As indicated.
3. Manholes shall be in accordance with Lee's Summit, Missouri Standard Drawings.

2.11 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R, and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.

2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

2.12 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

- A. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.

- B. Sloped-Invert, Polymer-Concrete Systems:

1. Channel Sections:

- a. Interlocking-joint, precast, modular units with end caps.
- b. Width and depth as indicated, rounded bottom, with built-in invert slope as indicated and with outlets in quantities, sizes, and locations indicated.
- c. Extension sections necessary for required depth.
- d. Frame: Include gray-iron or steel frame for grate.

2. Grates:

- a. Manufacturer's designation "Medium Duty," with slots or perforations that fit recesses in channels.

3. Covers: Solid gray iron if indicated.

4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

2.13 CATCH BASINS

- A. Standard Precast Concrete Catch Basins:

1. Made of materials and dimensions according to Lee's Summit, Missouri Standard Drawings and Specifications.

2.14 STORMWATER INLETS

- A. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to Lee's Summit, Missouri Standard Drawings and Specifications.

2.15 PIPE OUTLETS

- A. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.

- B. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
- C. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
- B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
- F. Install gravity-flow, nonpressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow.
 - 2. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - 3. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 - 4. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
 - 5. Install PE corrugated sewer piping according to ASTM D 2321.
 - 6. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
 - 7. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

- G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Expansion joints.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. 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.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
5. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
6. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
7. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
8. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
- B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding earth grade.
- C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.5 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.
- D. Set tops of frames and covers flush with finished surface of manholes.

3.6 CATCH BASIN INSTALLATION

- A. Set frames and grates to elevations indicated.

3.7 STORMWATER INLET AND OUTLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
- B. Construct riprap of broken stone, as indicated.
- C. Install outlets that spill onto grade, anchored with concrete, where indicated.
- D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
- E. Construct energy dissipaters at outlets, as indicated.

3.8 CONCRETE PLACEMENT

- A. Place cast-in-place concrete according to ACI 318.

3.9 CHANNEL DRAINAGE SYSTEM INSTALLATION

- A. Install with top surfaces of components, except piping, flush with finished surface.
- B. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturers.
- C. Embed channel sections and drainage specialties in 4-inch minimum concrete around bottom and sides.
- D. Fasten grates to channel sections if indicated.
- E. Assemble channel sections with flanged or interlocking joints.

3.10 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate reports for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.

- e. Exfiltration: Water leakage from or around piping.
- 3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
- 4. Reinspect and repeat the procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Test completed piping systems according to requirements of authorities having jurisdiction.
 - 3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
 - 4. Submit separate report for each test.
 - 5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
 - b. Option: Test plastic piping according to ASTM F 1417.
 - c. Option: Test concrete piping according to ASTM C 924.
- C. Leaks and loss in test pressure constitute defects that must be repaired.
- D. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

END OF SECTION 334100

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