

PROJECT MANUAL
Volume 2

Lee's Summit Joint Operations Facility
2 NE Tudor Road
Lee's Summit, MO 64086

PACKAGE 2: CONSTRUCTION SET
(Package 1 included for reference)

HW Project #: 138191
Issue Date: November 1, 2024

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PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Mechanical sleeve seals.
 - 3. Grout.
 - 4. Concrete bases.
 - 5. Supports and anchorages.

1.2 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.

1.3 SUBMITTALS

- A. Welding certificates.

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. 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.

1.5 GENERAL COORDINATION PROCEDURES

- A. Coordination: Each contractor shall coordinate its construction operations with those of other contractors and entities to ensure efficient and orderly installation of each part of the Work. Each contractor shall coordinate its operations with operations, included in different Sections, that depend on each other for proper installation, connection, and operation.
 1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
 2. Coordinate installation of different components with other contractors to ensure maximum performance and accessibility for required maintenance, service, and repair.
 3. Make adequate provisions to accommodate items scheduled for later installation.
- B. Prepare memoranda for distribution to each party involved, outlining special procedures required for coordination. Include such items as required notices, reports, and list of attendees at meetings.
 1. Prepare similar memoranda for Construction Manager and separate contractors if coordination of their Work is required.
- C. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and activities of other contractors to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
 1. Preparation of Contractor's construction schedule.
 2. Preparation of the schedule of values.
 3. Installation and removal of temporary facilities and controls.
 4. Delivery and processing of submittals.
 5. Progress meetings.
 6. Preinstallation conferences.
 7. Project closeout activities.
 8. Startup and adjustment of systems.
- D. Conservation: Coordinate construction activities to ensure that operations are carried out with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste.
 1. Salvage materials and equipment involved in performance of, but not actually incorporated into, the Work. See other Sections for disposition of salvaged materials that are designated as Owner's property.

1.6 COORDINATION DRAWINGS

- A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely shown on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.
 1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:
 - a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe relationship of various systems and components.
 - b. Coordinate the addition of trade-specific information to the coordination drawings by multiple contractors in a sequence that best provides for coordination of the information and resolution of conflicts between installed components before submitting for review.
 - c. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
 - d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
 - e. Show location and size of access doors required for access to concealed dampers, valves, and other controls.
 - f. Indicate required installation sequences.
 - g. Indicate dimensions shown on the Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternate sketches to Architect indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
- B. Coordination Drawing Organization: Organize coordination drawings as follows:
 1. Floor Plans and Reflected Ceiling Plans: Show architectural and structural elements, and mechanical, plumbing, fire-protection, fire-alarm, and electrical Work. Show locations of visible ceiling-mounted devices relative to acoustical ceiling grid. Supplement plan drawings with section drawings where required to adequately represent the Work.
 2. Plenum Space: Indicate subframing for support of ceiling and wall systems, mechanical and electrical equipment, and related Work. Locate components within ceiling plenum to accommodate layout of light fixtures indicated on Drawings. Indicate areas of conflict between light fixtures and other components.
 3. Mechanical Rooms: Provide coordination drawings for mechanical rooms showing plans and elevations of mechanical, plumbing, fire-protection, fire-alarm, and electrical equipment.
 4. Structural Penetrations: Indicate penetrations and openings required for all disciplines.
 5. Slab Edge and Embedded Items: Indicate slab edge locations and sizes and locations of embedded items for metal fabrications, sleeves, anchor bolts, bearing plates, angles, door floor closers, slab depressions for floor finishes, curbs and housekeeping pads, and similar items.
 6. Mechanical and Plumbing Work: Show the following:

- a. Sizes and bottom elevations of ductwork, piping, and conduit runs, including insulation, bracing, flanges, and support systems.
 - b. Dimensions of major components, such as dampers, valves, diffusers, access doors, cleanouts and electrical distribution equipment.
 - c. Fire-rated enclosures around ductwork.
7. Electrical Work: Show the following:
 - a. Runs of vertical and horizontal conduit 1-1/4 inches in diameter and larger.
 - b. Light fixture, exit light, emergency battery pack, smoke detector, and other fire-alarm locations.
 - c. Panel board, switch board, switchgear, transformer, busway, generator, and motor control center locations.
 - d. Location of pull boxes and junction boxes, dimensioned from column center lines.
8. Fire-Protection System: Show the following:
 - a. Locations of standpipes, mains piping, branch lines, pipe drops, and sprinkler heads.
9. Review: Architect will review coordination drawings to confirm that the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Architect determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Architect will so inform Contractor, who shall make changes as directed and resubmit.
10. Coordination Drawing Prints: Prepare coordination drawing prints according to requirements in Division 01 Section "Submittal Procedures."

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 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.

2.3 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
- B. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
- C. Pressure Plates: Carbon steel or stainless steel. Include two for each sealing element.
- D. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating or stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

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, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

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. 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.
- 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 annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast-iron "wall pipes" for sleeves 6 inches 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 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 Division 07 Section "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.

3.3 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions.
 - 1. Construct concrete bases a minimum of 4 inches and a maximum of 6 inches deep, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 7. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete" or "Miscellaneous Cast-in-Place Concrete."

3.4 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 fire-suppression materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.5 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.

3.6 GROUTING

- A. Mix and install grout for fire-suppression 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 210500

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

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 minimum thickness; round tube closed with welded longitudinal joint.
- F. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- G. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg. Co.
 - 2. Zurn Industries, LLC.
- B. Description: Manufactured, 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. Metraflex Company (The).
 - 4. Pipeline Seal and Insulator, Inc.
 - 5. Proco Products, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 1. Sealing Elements: EPDM-rubber or NBR 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 or stainless steel.
 - 3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, or stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. HOLDRITE.
- B. 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, 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 annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. 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 annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."

3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using 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. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves, galvanized-steel-pipe sleeves, or sleeve-seal fittings.
 - b. Piping NPS 6 and Larger: Galvanized-steel wall sleeves or galvanized-steel-pipe sleeves.
 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, galvanized-steel wall sleeves with sleeve-seal system, galvanized-steel-pipe sleeves with sleeve-seal system, or sleeve-seal fittings.

- 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, galvanized-steel wall sleeves with sleeve-seal system, or galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves with sleeve-seal system, galvanized-steel wall sleeves with sleeve-seal system, galvanized-steel-pipe sleeves with sleeve-seal system, or sleeve-seal fittings.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves with sleeve-seal system, galvanized-steel wall sleeves with sleeve-seal system, galvanized-steel-pipe sleeves with sleeve-seal system, or galvanized-steel-pipe sleeves.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves, stack-sleeve fittings, or sleeve-seal fittings.
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or stack-sleeve fittings.
5. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product 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.
- D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
- E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

- A. One-Piece Floor Plates: Cast-iron flange.
- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of 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. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and polished, chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - h. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
- 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. Two-piece ball valves with indicators.
 - 2. Bronze butterfly valves with indicators.
 - 3. Iron butterfly valves with indicators.
 - 4. Check valves.
 - 5. Bronze OS&Y gate valves.
 - 6. Iron OS&Y gate valves.
 - 7. NRS gate valves.
 - 8. Indicator posts.
 - 9. Trim and drain valves.

1.3 DEFINITIONS

- A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- B. NRS: Nonrising stem.
- C. OS&Y: Outside screw and yoke.
- D. SBR: Styrene-butadiene rubber.

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, and weld ends.
 - 3. Set valves open to minimize exposure of functional surfaces.

- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles or stems as lifting or rigging points.
- D. Protect flanges and specialties from moisture and dirt.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. UL Listed: Valves shall be listed in UL's "Online Certifications Directory" under the headings listed below and shall bear UL mark:
 - 1. Main Level: HAMV - Fire Main Equipment.
 - a. Level 1: HCBZ - Indicator Posts, Gate Valve.
 - b. Level 1: HLOT - Valves.
 - 1) Level 3: HLUG - Ball Valves, System Control.
 - 2) Level 3: HLXS - Butterfly Valves.
 - 3) Level 3: HMER - Check Valves.
 - 4) Level 3: HMRZ - Gate Valves.
 - 2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.
 - a. Level 1: VQGU - Valves, Trim and Drain.
- 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.
 - a) Single check valves.
 - 3) Miscellaneous valves.
- C. Source Limitations for Valves: Obtain valves for each valve type from single manufacturer.
- D. ASME Compliance:

1. ASME B16.1 for flanges on iron valves.
 2. ASME B1.20.1 for threads for threaded-end valves.
 3. ASME B31.9 for building services piping valves.
- E. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- F. NFPA Compliance: Comply with NFPA 24 for valves.
- G. Valve Pressure Ratings: Not less than the minimum pressure rating indicated or higher as required by system pressures.
- H. Valve Sizes: Same as upstream piping unless otherwise indicated.
- I. Valve Actuator Types:
1. Worm-gear actuator with handwheel for quarter-turn valves, except for trim and drain valves.
 2. Handwheel: For other than quarter-turn trim and drain valves.
 3. Handlever: For quarter-turn trim and drain valves NPS 2 and smaller.

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. NIBCO INC.
 2. Victaulic Company.
- B. Description:
1. UL 1091, except with ball instead of disc and FM Global standard for indicating valves (butterfly or ball type), Class Number 1112.
 2. Minimum Pressure Rating: 175 psig.
 3. Body Design: Two piece.
 4. Body Material: Forged brass or bronze.
 5. Port Size: Full or standard.
 6. Seats: PTFE.
 7. Stem: Bronze or stainless steel.
 8. Ball: Chrome-plated brass.
 9. Actuator: Worm gear or traveling nut.
 10. Supervisory Switch: Internal or external.
 11. End Connections for Valves NPS 1 through NPS 2: Threaded ends.
 12. End Connections for Valves NPS 2-1/2: Grooved ends.

2.3 BRONZE BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Globe Fire Sprinkler Corporation.
 2. Milwaukee Valve Company.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 1112.
2. Minimum: Pressure rating: 175 psig.
3. Body Material: Bronze.
4. Seat Material: EPDM.
5. Stem Material: Bronze or stainless steel.
6. Disc: Bronze or stainless steel with EPDM coating.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Ends Connections for Valves NPS 1 through NPS 2: Threaded ends.
10. Ends Connections for Valves NPS 2-1/2: Grooved ends.

2.4 IRON BUTTERFLY VALVES WITH INDICATORS

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

1. Anvil International.
2. Globe Fire Sprinkler Corporation.
3. Kennedy Valve Company; a division of McWane, Inc.
4. NIBCO INC.
5. Tyco Fire & Building Products LP.
6. Victaulic Company.
7. Zurn Industries, LLC.

B. Description:

1. Standard: UL 1091 and FM Global standard for indicating valves, (butterfly or ball type), Class Number 112.
2. Minimum Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron with nylon, EPDM, epoxy, or polyamide coating.
4. Seat Material: EPDM.
5. Stem: Stainless steel.
6. Disc: Ductile iron, nickel plated and EPDM or SBR coated.
7. Actuator: Worm gear or traveling nut.
8. Supervisory Switch: Internal or external.
9. Body Design: Lug or wafer or grooved-end connections.

2.5 CHECK VALVES

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

1. Anvil International.
2. Fire Protection Products, Inc.
3. Globe Fire Sprinkler Corporation.
4. Kennedy Valve Company; a division of McWane, Inc.
5. Mueller Co.
6. NIBCO INC.

7. Reliable Automatic Sprinkler Co., Inc. (The).
8. Tyco Fire & Building Products LP.
9. Victaulic Company.
10. Viking Corporation.
11. Watts; a Watts Water Technologies company.
12. Zurn Industries, LLC.

B. Description:

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

2.6 BRONZE OS&Y GATE VALVES

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

1. Milwaukee Valve Company.
2. NIBCO INC.
3. Zurn Industries, LLC.

B. Description:

1. Standard: UL 262 and FM Global standard for fire-service water control valves (OS&Y- and NRS-type gate valves).
2. Minimum Pressure Rating: 175 psig.
3. Body and Bonnet Material: Bronze or brass.
4. Wedge: One-piece bronze or brass.
5. Wedge Seat: Bronze.
6. Stem: Bronze or brass.
7. Packing: Non-asbestos PTFE.
8. Supervisory Switch: External.
9. End Connections: Threaded.

2.7 IRON OS&Y GATE VALVES

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

1. American Cast Iron Pipe Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Hammond Valve.
4. Kennedy Valve Company; a division of McWane, Inc.
5. Mueller Co.

6. NIBCO INC.
7. Victaulic Company.
8. Watts; a Watts Water Technologies company.
9. Zurn Industries, LLC.

B. Description:

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

2.8 NRS GATE VALVES

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

1. American Cast Iron Pipe Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.
3. Kennedy Valve Company; a division of McWane, Inc.
4. Mueller Co.
5. NIBCO INC.
6. Victaulic Company.
7. Zurn Industries, LLC.

B. Description:

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

2.9 INDICATOR POSTS

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

1. American Cast Iron Pipe Company.
2. Clow Valve Company; a subsidiary of McWane, Inc.

3. Kennedy Valve Company; a division of McWane, Inc.
4. Mueller Co.
5. NIBCO INC.

B. Description:

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

2.10 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Fire Protection Products, Inc.
 - c. Fire-End & Croker Corporation.
 - d. KITZ Corporation.
 - e. Legend Valve & Fitting, Inc.
 - f. Milwaukee Valve Company.
 - g. NIBCO INC.
 - h. Potter Roemer LLC.
 - i. Red-White Valve Corporation.
 - j. Tyco Fire & Building Products LP.
 - k. Victaulic Company.
 - l. Watts; a Watts Water Technologies company.
 - m. Zurn Industries, LLC.
2. Description:
 - a. Pressure Rating: 175 psig or 250 psig as required for system.
 - b. Body Design: Two piece.
 - c. Body Material: Forged brass or bronze.
 - d. Port size: Full or standard.
 - e. Seats: PTFE.
 - f. Stem: Bronze or stainless steel.
 - g. Ball: Chrome-plated brass.
 - h. Actuator: Handlever.
 - i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
 - j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

B. Angle Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire Protection Products, Inc.

- b. NIBCO INC.
 - c. United Brass Works, Inc.
2. Description:
- a. Pressure Rating: 175 psig or 250 psig as required for system.
 - 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- a. NIBCO INC.
 - b. United Brass Works, Inc.
2. Description:
- a. Pressure Rating: 175 psig or 250 psig as required for system.
 - b. Body Material: Bronze with integral seat and screw-in bonnet.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc Holder and Nut: Bronze.
 - f. Disc Seat: Nitrile.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

- A. Comply with requirements in the following Sections for specific valve installation requirements and applications:
 - 1. Section 211100 "Facility Fire-Suppression Water-Service Piping" for application of valves in fire-suppression water-service piping outside the building.
 - 2. Section 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
 - 3. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
 - 4. Section 211316 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.
- B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
- 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.
- H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.
- I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 210523

SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment-Label Schedule: Include a listing of all equipment to be labeled and the proposed content for each label.
- D. Valve Schedules: Valve numbering scheme.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
 - 2. Letter Color: White.
 - 3. Background Color: Red.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- C. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
- B. Letter Color: Black unless required otherwise by AHJ.
- C. Background Color: Yellow unless required otherwise by AHJ.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel 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 according to ASME A13.1.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

- C. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: Size letters according to ASME A13.1 for piping, at least 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances.
- E. Pipe-Label Colors:
 - 1. Background Color: Safety Red.
 - 2. Letter Color: White.

2.4 STENCILS

- A. Stencils for Piping:
 - 1. Lettering Size: Size letters according to ASME A13.1 for piping, at least 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances.
 - 2. Stencil Material: Fiberboard or metal.
 - 3. Stencil Paint: Safety Red, exterior, gloss, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
 - 4. Identification Paint: White, exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.

2.5 VALVE TAGS

- A. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032 inch; stainless steel, 0.025 inch; aluminum, 0.032 inch; or anodized aluminum, 0.032 inch thick, with predrilled holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain, beaded chain, or S-hook.
 - 3. Valve-Tag Color: Safety Red.
 - 4. Letter Color: White.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

- A. Description: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: 3 by 5-1/4 inches minimum.
 - 2. Fasteners: Brass grommet and wire or reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be installed.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

3.3 EQUIPMENT LABEL INSTALLATION

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

3.4 PIPE LABEL INSTALLATION

- A. Piping: Painting of piping is specified in Section 099123 "Interior Painting," and Section 099600 "High-Performance Coatings."
- B. Stenciled Pipe-Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.

- C. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit a view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in fire-suppression piping systems. List tagged valves in a valve-tag schedule.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and with captions similar to those indicated in "Valve-Tag Size and Shape" Subparagraph below:
 - 1. Valve-Tag Size and Shape:
 - a. Fire-Suppression Standpipe: 2 inches, round.
 - b. Wet-Pipe Sprinkler System: 2 inches, round.
 - c. Dry-Pipe Sprinkler System: 2 inches, round.

3.6 WARNING-TAG INSTALLATION

- A. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 210553

SECTION 211100 - FACILITY FIRE-SUPPRESSION WATER-SERVICE 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 fire-suppression water-service piping and related components outside the building and service entrance piping through floor into the building and the following:
 - 1. Pipes, fittings, and specialties.
 - 2. Fire-suppression specialty valves.
 - 3. Concrete vaults.
 - 4. Protective enclosures.
 - 5. Alarm devices.
- B. Utility-furnished products include water meters that are furnished to the site, ready for installation.
- C. Related Requirements:
 - 1. Section 211119 "Fire-Department Connections" for exposed-, flush-, and yard-type, fire-department connections.
 - 2. Section 211200 "Fire-Suppression Standpipes" for fire-suppression standpipes inside the building.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.
 - 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: For piping and specialties including relation to other services in same area, drawn to scale. Show piping and specialty sizes and valves, meter and specialty locations, and elevations.
- B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements of utility company supplying the water. Include tapping of water mains and backflow prevention.
2. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

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

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with FM Global's "Approval Guide" or UL's "Fire Protection Equipment Directory" for fire-service-main products.

E. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-suppression water-service piping.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:

1. Ensure that valves are dry and internally protected against rust and corrosion.
2. Protect valves against damage to threaded ends and flange faces.
3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:

1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store indoors and maintain temperature higher than ambient dew point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.

E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

PART 2 - PRODUCTS

2.1 DUCTILE-IRON PIPE AND FITTINGS

- A. Grooved-Joint, Ductile-Iron Pipe: AWWA C151, with cut, rounded-grooved ends.
- B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end.
- C. Grooved-End, Ductile-Iron Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Star Pipe Products.
 - c. Victaulic Company.
 - d. Pre-approved equal.
 - 2. Grooved-End, Ductile-Iron Fittings: ASTM A 47/A 47M, malleable-iron castings or ASTM A 536, ductile-iron castings with dimensions matching pipe.
 - 3. Grooved-End, Ductile-Iron-Piping Couplings: AWWA C606, for ductile-iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
- D. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 1. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- E. Flanges: ASME B16.1, Class 125, cast iron.

2.2 SPECIAL PIPE FITTINGS

- A. Ductile-Iron Flexible Expansion Joints:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. EBAA Iron, Inc.
 - b. Hays Fluid Controls; a division of ROMAC Industries Inc.
 - c. Star Pipe Products.
 - d. Pre-approved equal.
 - 2. Description: Compound, ductile-iron 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. Assemble components for offset and expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.
 - 3. Pressure Rating: 250 psig minimum.

2.3 ENCASEMENT FOR PIPING

- A. Standard: ASTM A 674 or AWWA C105.
- B. Material: High-density, cross-laminated PE film of 0.004-inch minimum thickness.
- C. Form: Sheet or tube.

2.4 ALARM DEVICES

- A. General: UL 753 and FM Global's "Approval Guide" listing, of types and sizes to mate and match piping and equipment.
- B. Water-Flow Indicators: Vane-type water-flow detector, rated for 250-psig working pressure; designed for horizontal or vertical installation; with two single-pole, double-throw circuit switches to provide 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 when cover is removed.
- C. Supervisory Switches: Single pole, double throw; designed to signal valve in other than fully open position.
- D. Pressure Switches: Single pole, double throw; designed to signal increase in pressure.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

- A. Comply with NFPA 24 for fire-service-main piping materials and installation.
- B. Install ductile-iron, water-service piping according to AWWA C600 and AWWA M41.
 - 1. Install encasement for piping according to ASTM A 674 or AWWA C105.
- C. Bury piping with depth of cover over top at least 36 inches, with top at least 12 inches below level of maximum frost penetration, and according to the following:
 - 1. Under Driveways: With at least 36 inches of cover over top.
 - 2. Under Railroad Tracks: With at least 48 inches of cover over top.
 - 3. In Loose Gravelly Soil and Rock: With at least 12 inches of additional cover.
- D. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.

- E. Extend fire-suppression water-service piping and connect to building fire-suppression water-service piping systems at locations and pipe sizes indicated.
 - 1. Terminate fire-suppression water-service piping within the building at the floor slab until building-water-piping systems are installed. Terminate piping with caps, plugs, or flanges as required for piping material. Make connections to building's fire-suppression water-service piping systems when those systems are installed.
- F. Install underground piping with restrained joints at horizontal and vertical changes in direction. Use restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports.
- G. Comply with requirements in Division 21 Sections for fire-suppression-water piping inside the building.
- H. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- I. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."

3.3 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure rating same as or higher than systems pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in tubing NPS 2 and smaller.
- C. Install flanges, flange adaptors, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of tubes and remove burrs.
- E. Remove scale, slag, dirt, and debris from outside and inside of pipes, tubes, and fittings before assembly.
- F. Ductile-Iron Piping, Gasketed Joints for Fire-Service-Main Piping: UL 194.
- G. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with bolts according to ASME B31.9.
- H. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.
- I. Do not use flanges or unions for underground piping.

3.4 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints. Anchorages and restrained-joint types that may be used include the following:

1. Concrete thrust blocks.
 2. Locking mechanical joints.
 3. Pipe clamps and tie rods.
- B. Install anchorages for tees, plugs and caps, bends, crosses, valves, and hydrant branches in fire-suppression water-service piping according to NFPA 24 and the following:
1. Gasketed-Joint, Ductile-Iron, Water-Service Piping: According to AWWA C600.
- C. Apply full coat of asphalt or other acceptable corrosion-resistant material to surfaces of installed ferrous anchorage devices.

3.5 FIRE-DEPARTMENT CONNECTION INSTALLATION

- A. Install ball drip valves at each check valve for fire-department connection to mains.
- B. Install protective pipe bollards on two sides of each freestanding fire-department connection. Pipe bollards are specified in Section 055000 "Metal Fabrications."

3.6 ALARM DEVICE INSTALLATION

- A. General: Comply with NFPA 24 for devices and methods of valve supervision. Underground valves with valve box do not require supervision.
- B. Supervisory Switches: Supervise valves in open position.
1. Valves: Grind away portion of exposed valve stem. Bolt switch, with plunger in stem depression, to OS&Y gate-valve yoke.
 2. Indicator Posts: Drill and thread hole in upper-barrel section at target plate. Install switch, with toggle against target plate, on barrel of indicator post.
- C. Locking and Sealing: Secure unsupervised valves as follows:
1. Valves: Install chain and padlock on open OS&Y gate valve.
 2. Post Indicators: Install padlock on wrench on indicator post.
- D. Pressure Switches: Drill and thread hole in exposed barrel of fire hydrant. Install switch.
- E. Water-Flow Indicators: Install in water-service piping in vault. Select indicator with saddle and vane matching pipe size. Drill hole in pipe, insert vane, and bolt saddle to pipe.
- F. Connect alarm devices to building's fire-alarm system. Wiring and fire-alarm devices are specified in Section 283111 "Digital, Addressable Fire-Alarm System."

3.7 CONNECTIONS

- A. Connect fire-suppression water-service piping to interior fire-suppression piping.

3.8 FIELD QUALITY CONTROL

- A. Use test procedure compliant with NFPA 24 as prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described below.
- B. Piping Tests: Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently. Fill pipeline 24 hours before testing and apply test pressure to stabilize system. Use only potable water.
- C. Hydrostatic Tests: Test at not less than one-and-one-half times the working pressure for two hours.
 - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for one hour; decrease to zero psig. Slowly increase again to test pressure and hold for one more hour. Maximum allowable leakage is 2 quarts per hour per 100 joints. Remake leaking joints with new materials and repeat test until leakage is within allowed limits.
- D. Prepare test and inspection reports.

3.9 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground fire-suppression water-service piping. Locate below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."
- B. Permanently attach equipment nameplate or marker indicating plastic fire-suppression water-service piping or fire-suppression water-service piping with electrically insulated fittings, on main electrical meter panel. Comply with requirements for identifying devices in Section 210553 "Identification for Fire-Suppression Piping and Equipment."

3.10 CLEANING

- A. Clean and disinfect fire-suppression water-service piping as follows:
 - 1. Purge new piping systems and parts of existing systems that have been altered, extended, or repaired before use.
 - 2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
 - 3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651 or do as follows:
 - a. Fill system or part of system with water/chlorine solution containing at least 50 ppm of chlorine; isolate and allow it to stand for 24 hours.
 - b. Drain system or part of system of previous solution and refill with water/chlorine solution containing at least 200 ppm of chlorine; isolate and allow it to stand for three hours.

- c. After standing time, flush system with clean, potable water until no chlorine remains in water coming from system.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedure if biological examination shows evidence of contamination.
- B. Prepare reports of purging and disinfecting activities.

3.11 PIPING SCHEDULE

- A. Underground fire-suppression water-service piping NPS 6 to NPS 12 shall be the following:
 - 1. Grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.
 - 2. Mechanical-joint, ductile-iron pipe; mechanical-joint, ductile- or gray-iron, standard-pattern fittings; glands, gaskets, and bolts; and gasketed joints.
- B. Aboveground fire-suppression water-service piping NPS 5 to NPS 12 shall be grooved-end, ductile-iron pipe; grooved-end, ductile-iron pipe appurtenances; and grooved joints.

END OF SECTION 211100

SECTION 211313 - WET-PIPE SPRINKLER 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. Pipes, fittings, and specialties.
2. Cover system for sprinkler piping.
3. Specialty valves.
4. Sprinklers.
5. Alarm devices.
6. Manual control stations.
7. Control panels.
8. Pressure gages.

- B. Related Requirements:

1. Section 230523 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.

1.4 ACTION SUBMITTALS

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

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: For wet-pipe sprinkler systems.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

- C. Delegated-Design Submittal: For wet-pipe sprinkler systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the other trade items are shown and coordinated with each other, using input from installers of the items involved.
- B. Qualification Data: For qualified Installer and professional engineer.
- C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- D. Welding certificates.
- E. Fire-hydrant flow test report.
- F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wet-pipe sprinkler systems and specialties to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.8 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 2010 ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 - 1. NFPA 13.
- B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.
 - 1. Available fire-hydrant flow test records indicate the following conditions:
 - a. Date: 8/15/2024.
 - b. Location of Fire Hydrant: NW Sloan between Main St. and NE Tudor Rd.
 - c. Static Pressure at Residual Fire Hydrant R: 85 psi.
 - d. Measured Flow at Flow Fire Hydrant F: 2100 gpm.
 - e. Residual Pressure at Residual Fire Hydrant R: 62 psi.
 - 2. Sprinkler system design shall be approved by authorities having jurisdiction.
 - a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
 - b. Sprinkler Occupancy Hazard Classifications:
 - 1) Building Service Areas: Ordinary Hazard, Group 1.
 - 2) Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - 3) General Storage Areas: Ordinary Hazard, Group 1.
 - 4) Laundries: Ordinary Hazard, Group 1.
 - 5) Machine Shops: Ordinary Hazard, Group 2.
 - 6) Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
 - 7) Office and Public Areas: Light Hazard.
 - 8) Plastics Processing Areas: Extra Hazard, Group 2.
 - 9) Printing Plants: Extra Hazard, Group 1.
 - 10) Solvent Cleaning Areas: Extra Hazard, Group 2.
 - 3. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.
 - c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. area.
 - d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500-sq. ft. area.
 - e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500-sq. ft. area.
 - f. Special Occupancy Hazard: As determined by authorities having jurisdiction.
 - 4. Minimum Density for Deluge-Sprinkler Piping Design:
 - a. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over entire area.
 - b. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over entire area.

- c. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over entire area.
 - d. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over entire area.
 - e. Special Occupancy Hazard: As determined by authorities having jurisdiction.
- 5. Maximum Protection Area per Sprinkler: According to UL listing.
 - 6. Maximum Protection Area per Sprinkler:
 - a. Office Spaces: 225 sq. ft..
 - b. Storage Areas: 130 sq. ft.
 - c. Mechanical Equipment Rooms: 130 sq. ft.
 - d. Electrical Equipment Rooms: 130 sq. ft.
 - e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

2.2 STEEL PIPE AND FITTINGS

- A. Standard-Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 30, Black-Steel Pipe: ASTM A 135/A 135M; ASTM A 795/A 795M, 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. Thinwall Galvanized- and Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
- D. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.
- E. Nonstandard OD, Thinwall Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M thinwall with plain ends and wall thickness less than Schedule 10.
- F. Galvanized- and Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- G. Galvanized- and Uncoated-Steel Couplings: ASTM A 865/A 865M, threaded.
- H. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- I. Malleable- or Ductile-Iron Unions: UL 860.
- J. Cast-Iron Flanges: ASME 16.1, Class 125.
- K. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
 - 1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick; ASME B16.21, nonmetallic and asbestos free; or EPDM rubber gasket.
 - a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.
 - b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.

2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
- L. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
1. 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.
- M. Grooved-Joint, Steel-Pipe Appurtenances:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Corcoran Piping System Co.
 - c. National Fittings, Inc.
 - d. Shurjoint Piping Products.
 - e. Smith-Cooper International.
 - f. Tyco Fire & Building Products LP.
 - g. Victaulic Company.
 2. Pressure Rating: 250-psig minimum.
 3. Galvanized or Painted Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.
- N. Steel Pressure-Seal Fittings: UL 213, FM Global-approved, 175-psig pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Victaulic Company.
- 2.3 COVER SYSTEM FOR SPRINKLER PIPING
- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. DecoShield Systems, Inc.
- B. Description: System of support brackets and covers made to protect sprinkler piping.
- C. Brackets: Glass-reinforced nylon.
- D. Covers: Extruded-PVC sections of length, shape, and size required for size and routing of CPVC piping.

2.4 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating:
 - 1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
- C. Body Material: Cast or ductile iron.
- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Alarm Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco Fire & Building Products LP.
 - d. Venus Fire Protection Ltd.
 - e. Victaulic Company.
 - f. Viking Corporation.
 - 2. Standard: UL 193.
 - 3. Design: For horizontal or vertical installation.
 - 4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages,[retarding chamber,] and fill-line attachment with strainer.
 - 5. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
 - 6. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
 - 7. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Automatic (Ball Drip) Drain Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire & Building Products LP.
 - 2. Standard: UL 1726.
 - 3. Pressure Rating: 175-psig minimum.
 - 4. Type: Automatic draining, ball check.
 - 5. Size: NPS 3/4.
 - 6. End Connections: Threaded.

2.5 SPRINKLER PIPING SPECIALTIES

A. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. National Fittings, Inc.
 - c. Shurjoint Piping Products.
 - d. Tyco Fire & Building Products LP.
 - e. Victaulic Company.
2. Standard: UL 213.
3. Pressure Rating: 300 psig.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing Inc.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 300 psig.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkhart Brass Mfg. Co., Inc.
 - b. Fire-End & Croker Corporation.
 - c. Potter Roemer LLC.
2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.

7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing Inc.
 - b. Triple R Specialty.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company.
 - e. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 300 psig.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aegis Technologies, Inc.
 - b. CECA, LLC.
 - c. Corcoran Piping System Co.
 - d. Merit Manufacturing.
2. Standard: UL 1474.
3. Pressure Rating: 250-psig minimum.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fivalco Inc.
 - b. FlexHead Industries, Inc.
 - c. Gateway Tubing, Inc.
 - d. Victaulic Company.
2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 300 psig.
5. Size: Same as connected piping, for sprinkler.

2.6 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Globe Fire Sprinkler Corporation.
 - 2. Reliable Automatic Sprinkler Co., Inc. (The).
 - 3. Tyco Fire & Building Products LP.
 - 4. Victaulic Company.
 - 5. Viking Corporation.
- B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- C. Pressure Rating for Automatic Sprinklers: 175-psig minimum.
- D. Automatic Sprinklers with Heat-Responsive Element:
 - 1. Early-Suppression, Fast-Response Applications: UL 1767.
 - 2. Nonresidential Applications: UL 199.
 - 3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- E. Sprinkler Finishes: Chrome plated, bronze, and painted.
- F. Special Coatings: Corrosion-resistant paint.
- G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- H. Sprinkler Guards:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. Viking Corporation.
 - 2. Standard: UL 199.
 - 3. Type: Wire cage with fastening device for attaching to sprinkler.

2.7 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Water-Motor-Operated Alarm:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Tyco Fire & Building Products LP.
 - c. Victaulic Company.
 - d. 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: 8-1/2-inches diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4.
8. Outlet: NPS 1 drain connection.

C. Electrically Operated Alarm Bell:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - b. Notifier.
 - c. Potter Electric Signal Company, LLC.
2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 8-inch minimum- diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ADT Security Services, Inc.
 - b. McDonnell & Miller.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
 - e. Viking Corporation.
 - f. Watts; a Watts Water Technologies company.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
5. Type: Paddle operated.

6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

E. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Barksdale, Inc.
 - b. Detroit Switch, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
 - e. Tyco Fire & Building Products LP.
 - f. United Electric Controls Co.
 - g. Viking Corporation.
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

F. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - b. Kennedy Valve Company; a division of McWane, Inc.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
2. Standard: UL 346.
3. Type: Electrically supervised.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design: Signals that controlled valve is in other than fully open position.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.8 PRESSURE GAGES

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

1. AGF Manufacturing Inc.
2. AMETEK, Inc.
3. Ashcroft Inc.
4. Brecco Corporation.
5. WIKA Instrument Corporation.

B. Standard: UL 393.

- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 300 psig.
- E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article.
- B. Report test results promptly and in writing.

3.2 SERVICE-ENTRANCE PIPING

- A. Connect sprinkler piping to water-service piping for service entrance to building. Comply with requirements for exterior piping in Section 211100 "Facility Fire-Suppression Water-Service Piping" for exterior piping.
- B. Install shutoff valve, pressure gage, drain, and other accessories indicated at connection to water-service piping.
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.3 PIPING INSTALLATION

- A. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated on approved working plans.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
 - 2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

- G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- K. Install alarm devices in piping systems.
- L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- M. Install pressure 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 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- N. Fill sprinkler system piping with water.
- O. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Section 210533 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 210700 "Fire-Suppression Systems Insulation."
- P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.

- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. 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. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- J. 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.
- K. Steel-Piping, Cut-Grooved Joints: Cut square-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 joints.
- L. 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.
- M. Steel-Piping, Pressure-Sealed Joints: Join Schedule 5 steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- N. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
- O. Copper-Tubing Grooved Joints: Roll rounded-edge groove in end of tube according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- P. Copper-Tubing, Pressure-Sealed Joints: Join copper tube and copper pressure-seal fittings with tools recommended by fitting manufacturer.
- Q. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

- R. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.
- S. 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. Apply primer.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

3.5 INSTALLATION OF COVER SYSTEM FOR SPRINKLER PIPING

- A. Install cover system, brackets, and cover components for sprinkler piping according to manufacturer's "Installation Manual" and NFPA 13 or NFPA 13R for supports.

3.6 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. Install valves in vertical position for proper direction of flow, in main supply to system.
 - 2. Install alarm valves with bypass check valve and retarding chamber drain-line connection.
 - 3. Install deluge valves in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.7 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels. Utilize minimum 3'-0" sprinkler flexible hose to allow precise centering of each sprinkler head.
- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
- C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.8 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.9 FIELD QUALITY CONTROL

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

3.10 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.11 DEMONSTRATION

- A. [Engage a factory-authorized service representative to train] [Train] Owner's maintenance personnel to adjust, operate, and maintain [specialty valves] [and] [pressure-maintenance pumps].

3.12 PIPING SCHEDULE

- A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with [threaded ends, cast-iron threaded fittings, and threaded] [grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved] joints.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

- C. Copper-tube, extruded-tee connections may be used for tee branches in copper tubing instead of specified copper fittings. Branch-connection joints must be brazed.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, 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, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 3. Standard-weight or Schedule 30, black-steel pipe with plain ends; uncoated, plain-end-pipe fittings; and twist-locked joints.
 - 4. Standard-weight or Schedule 30, galvanized-steel pipe with plain ends; galvanized, plain-end-pipe fittings; and twist-locked joints.
 - 5. 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.
 - 6. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 7. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
- E. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4, 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, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 3. 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.
 - 4. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 5. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.
- F. Standard-pressure, wet-pipe sprinkler system, NPS 5 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, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
 - 3. 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.
 - 4. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 5. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.

G. High-pressure, wet-pipe sprinkler system, NPS 4 and smaller, shall be one of the following:

1. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.

H. High-pressure, wet-pipe sprinkler system, NPS 5 and larger, shall be one of the following:

1. Standard-weight or Schedule 30, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized-steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
3. Standard-weight or Schedule 30, black-steel pipe with plain ends; steel welding fittings; and welded joints.

3.13 SPRINKLER SCHEDULE

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

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Ceilings: Flush concealed sprinklers with painted white escutcheon.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Pendent, dry sprinklers or sidewall, dry sprinklers.
5. Deluge-Sprinkler Systems: Upright and pendent, open sprinklers.
6. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers.

END OF SECTION 211313

SECTION 212200 - CLEAN-AGENT FIRE-EXTINGUISHING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Valves.
3. Extinguishing-agent containers.
4. Fire-extinguishing clean agent.
5. Discharge nozzles.
6. Manifold and orifice unions.
7. Fire control panels.
8. Detection devices.
9. Manual stations.
10. Switches.
11. Alarm devices.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: Prepare in accordance with requirements of NFPA 2001, to include, but not be limited to, the following:

1. Include plans, elevations, sections, and attachment details.
2. Include design calculations.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, manufacturer-required clearances, method of field assembly, components, and location and size of each field connection.
4. Include diagrams for power, signal, and control wiring.
5. Permit-Approved Documents: Working plans and hydraulic calculations approved by authorities having jurisdiction.

C. Delegated-Design Submittal: For clean-agent fire-extinguishing systems indicated to comply with performance and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades. Coordinate for enclosure integrity in accordance with NFPA 2001 requirements.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For clean-agent fire-extinguishing system to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra materials to Owner.
 - 1. Detection Devices: Not less than 20 percent of amount of each type installed.
 - 2. Container Valves: Not less than 10 percent of amount of each size and type installed.
 - 3. Nozzles: Not less than 20 percent of amount of each type installed.
 - 4. Extinguishing Agent: Not less than 100 percent of amount installed in largest hazard area. Include pressure-rated containers with valves.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. UL Compliance: Provide equipment listed in UL's "Fire Protection Equipment Directory."

2.2 CLEAN-AGENT SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Fike Corporation.
 - 2. Kidde; Carrier Global Corporation.
 - 3. Siemens Industry, Inc., Building Technologies Division.
- B. Source Limitations: Obtain clean-agent systems from single source from single manufacturer.
- C. Description: Clean-agent fire-extinguishing system shall be an engineered system for total flooding of the hazard area.
- D. Delegated Design: Design clean-agent fire-extinguishing system and obtain approval from authorities having jurisdiction. Design system for Class A fires as appropriate for areas being protected, and include safety factor. Use clean agent indicated and in concentration suitable for normally occupied areas.
- E. Performance Requirements, Discharge ECARO-25: Within 10 seconds and maintain ~~6.7~~ **8.7** percent concentration by volume at 70 deg F for 10-minute holding time in hazard areas.
- F. Performance Requirements, Discharge FK-5-1-12: Within 10 seconds and maintain 6.6 percent concentration by volume at 70 deg F (21 deg C) for 10-minute holding time in hazard areas.

- G. Verified Detection: Devices located in single zone. Sound alarm on activating single-detection device, and discharge extinguishing agent on actuating second-detection device.
- H. System Operating Sequence for ionization smoke detectors or photoelectric smoke detectors or combination of ionization and photoelectric smoke detectors:
 - 1. Actuating First Detector: Visual indication on annunciator panel. Energize audible and visual alarms (slow pulse), shut down air-conditioning and ventilating systems serving protected area, close doors in protected area, and send signal to fire-alarm system.
 - 2. Extinguishing-agent discharge will operate audible alarms and strobe lights inside and outside the protected area.
- I. Manual stations shall immediately discharge extinguishing agent when activated.
- J. Low-Agent Pressure Switch: Initiate trouble alarm if sensing less than set pressure.
- K. Power Transfer Switch: Transfer from normal to standby power source.

2.3 PIPE AND FITTINGS

- A. Piping, Valves, and Discharge Nozzles: Comply with types and standards listed in NFPA 2001, Section "Distribution," for charging pressure of system.
- B. Steel Pipe: ASTM A53/A53M, Type S, Grade B or ASTM A106/A106M, Grade A and Grade B; Schedule 40, Schedule 80, and Schedule 160, seamless steel pipe.
 - 1. Threaded Fittings:
 - a. Malleable-Iron Fittings: ASME B16.3, Class 300.
 - b. Flanges and Flanged Fittings: ASME B16.5, Class 300 unless Class 600 is indicated.
 - c. Fittings Working Pressure: 620 psig minimum.
 - d. Flanged Joints: Class 300 minimum.
 - 2. Forged-Steel Welding Fittings: ASME B16.11, Class 3000, socket pattern.
 - 3. Steel, Grooved-End Fittings: FM Approved and NRTL listed, ASTM A47/A47M malleable iron or ASTM A536 ductile iron, with dimensions matching steel pipe and ends factory grooved in accordance with AWWA C606.
- C. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch-maximum thickness unless thickness or specific material is indicated.
- D. Flange Bolts and Nuts: ASME B18.2.1, carbon steel.
- E. 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.

- F. Steel, Keyed Couplings: UL 213, AWWA C606, approved or listed for clean-agent service, and matching steel-pipe dimensions. Include ASTM A536, ductile-iron housing, rubber gasket, and steel bolts and nuts.

2.4 VALVES

- A. General Valve Requirements:
 - 1. UL listed or FM Approved for use in fire-protection systems.
 - 2. Compatible with type of clean agent used.
- B. Container Valves: With rupture disc or solenoid and manual-release lever, capable of immediate and total agent discharge and suitable for intended flow capacity.
- C. Valves in Sections of Closed Piping and Manifolds: Fabricate to prevent entrapment of liquid, or install valve and separate pressure relief device.
- D. Valves in Manifolds: Check valve; installed to prevent loss of extinguishing agent when container is removed from manifold.

2.5 EXTINGUISHING-AGENT CONTAINERS

- A. Description: Steel tanks complying with ASME Boiler and Pressure Vessel Code: Section VIII, for unfired pressure vessels. Include minimum working-pressure rating that matches system charging pressure, valve, pressure switch, and pressure gage.
 - 1. Finish: Manufacturer's standard color, enamel or epoxy paint.
 - 2. Manifold:
 - a. Fabricate with valves, pressure switches, selector switch, and connections for main- and reserve-supply banks of multiple storage containers.
 - 3. Storage-Tank Brackets: Factory- or field-fabricated retaining brackets consisting of steel straps and channels; suitable for container support, maintenance, and tank refilling or replacement.

2.6 FIRE-EXTINGUISHING CLEAN AGENT

- A. ECARO-25.
 - 1. Source Limitations: Obtain clean agents from single source from single manufacturer.
- B. FK-5-1-12 Clean Agent: Dodecafluoro-2-methylpentan-3-one.
 - 1. Source Limitations: Obtain clean agents from single source from single manufacturer.

2.7 DISCHARGE NOZZLES

- A. Description: Equipment manufacturer's standard one-piece brass or aluminum alloy of type, size, discharge pattern, and capacity required for application.
- B. Material: Corrosion-resistant metal.
- C. Stamped with orifice size and type.

2.8 FIRE CONTROL PANELS

- A. Description: **Addressable** FM Approved or NRTL listed, including equipment and features required for testing, supervising, and operating fire-extinguishing system.
- B. Power Requirements: 120/240 V ac; with electrical contacts for connection to system components and fire-alarm system, and transformer or rectifier as needed to produce power at voltage required for accessories and alarm devices.
- C. Enclosure: NEMA ICS 6, Type 1, enameled-steel cabinet.
 - 1. Mounting: Recessed flush with surface.
- D. Supervised Circuits: Separate circuits for each independent hazard area.
 - 1. Detection circuits equal to required number of zones, or addressable devices assigned to required number of zones.
 - 2. Manual pull-station circuit.
 - 3. Alarm circuit.
 - 4. Release circuit.
- E. Control-Panel Features:
 - 1. Electrical contacts for shutting down fans, activating dampers, and operating system electrical devices.
 - 2. Automatic switchover to standby power at loss of primary power.
 - 3. Storage container, low-pressure indicator.
 - 4. Service disconnect to interrupt system operation for maintenance with visual status indication on the annunciator panel.
- F. Annunciator Panel: ~~Graphic type showing protected, hazard area plans, as well as locations of detectors and alarm, and manual stations.~~ Include lamps to indicate device-initiating alarm, electrical contacts for connection to control panel, and stainless steel or aluminum enclosure.
- G. Standby Power: Sealed, valve-regulated, recombinant lead acid batteries with capacity to operate system for 24 hours and alarm for minimum of 15 minutes. Include automatic battery charger that has a varying charging rate between trickle and high depending on battery voltage, and that is capable of maintaining batteries fully charged. Include manual voltage control, dc voltmeter, dc ammeter, electrical contacts for connection to control panel, automatic transfer switch, and suitable enclosure.

2.9 DETECTION DEVICES

- A. Description: Comply with NFPA 2001, NFPA 72, and UL 268; 24 V dc, nominal.
- B. Ionization Detectors: Dual-chamber type, having sampling and referencing chambers, with smoke-sensing element.
- C. Photoelectric Detectors: LED light source and silicon photodiode receiving element.
- D. Signals to the Central Fire-Alarm Control Panel: Any type of local system trouble is reported to central fire-alarm control panel as a composite "trouble" signal. Alarms on each system zone are individually reported to central fire-alarm control panel as separately identified zones.

2.10 MANUAL STATIONS

- A. Description: Surface FM Approved or NRTL listed, with clear plastic hinged cover, 120-V ac or low-voltage compatible with controls. Include contacts for connection to control panel.
- B. Manual Release: "MANUAL RELEASE" caption, and red finish. Unit can manually discharge extinguishing agent with operating device that remains engaged until unlocked.

2.11 SWITCHES

- A. Description: FM Approved or NRTL listed, where available, 120-V ac or low-voltage compatible with controls. Include contacts for connection to control panel.
 - 1. Low-Agent Pressure Switches: Pneumatic operation.
 - 2. Power Transfer Switches: Key-operation selector, for transfer of release circuit signal from main supply to reserve supply.
 - 3. Door Closers: Magnetic retaining and release device or electrical interlock to cause door operator to drive the door closed.

2.12 ALARM DEVICES

- A. Description: FM Approved or NRTL listed, low voltage, and surface mounting. Comply with requirements in Section "Addressable Fire-Alarm Systems" for alarm and monitoring devices.
- B. Bells: Minimum 6-inch diameter.
- C. Horns: 90 to 94 dBA.
- D. Strobe Lights: Translucent lens, with "FIRE" or similar caption.
- E. Oxygen Deficiency Monitor.
 - 1. Sampling Method and Range: Diffusion, zero to 25 percent O₂.
 - 2. 24 V dc.
 - 3. Wall mounted with bracket.
 - 4. Built-in audible alarm 90 dBA.
 - 5. Backlit LCD.

6. 10-year no-calibration sensor.
7. No maintenance required.
8. Signal Outputs: Standard 4- to 20-mA analog.
9. Connections for system control data acquisition system and/or programmable logic controller.
10. Plus or minus 1 percent accuracy of full scale.
11. Operating temperature of minus 40 to plus 122 deg F.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with enclosure integrity requirements, installation tolerances, and other conditions affecting performance of the Work in accordance with NFPA 2001.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CLEAN-AGENT SYSTEM INSTALLATION

- A. Install clean-agent containers, piping, and other components level and plumb, in accordance with manufacturers' written instructions.
- B. Grooved Piping Joints: Groove pipe ends in accordance with AWWA C606 dimensions. Assemble grooved-end steel pipe and steel, grooved-end fittings with steel, keyed couplings and lubricant in accordance with manufacturer's written instructions.
- C. Install pipe and fittings, valves, and discharge nozzles in accordance with requirements listed in NFPA 2001, Section "Distribution."
 1. Install valves designed to prevent entrapment of liquid, or install pressure relief devices in valved sections of piping systems.
 2. Support piping using supports and methods in accordance with NFPA 13.
 3. Install control panels, detection system components, alarms, and accessories, in accordance with requirements listed in NFPA 2001, Section "Detection, Actuation, and Control Systems," as required for supervised system application.

3.3 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section "Low-Voltage Electrical Power Conductors and Cables."

- B. Ground equipment in accordance with Section "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
- E. Connect electrical devices to control panel and to building's fire-alarm system. Electrical power, wiring, and devices are specified in Section "Addressable Fire-Alarm Systems".

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section "Control-Voltage Electrical Power Cables."

3.6 IDENTIFICATION

- A. Identify system components and equipment. Comply with requirements for identification specified in Section 210553 "Identification for Fire-Suppression Piping and Equipment."
- B. Identify piping, extinguishing-agent containers, other equipment, and panels in accordance with NFPA 2001.
- C. Install signs at entry doors for protected areas to warn occupants that they are entering a room protected with a clean-agent fire-extinguishing system.
- D. Install signs at entry doors to advise persons outside the room the meaning of horn(s), bell(s), and strobe light(s) outside the protected space.

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
 - 1. After installing clean-agent fire-extinguishing system and after electrical circuitry has been energized, test for compliance in accordance with requirements listed in NFPA 2001, Section "Approval of Installation."
 - 2. Clean-agent fire-extinguishing system and associated protected enclosure will be considered defective if either does not pass required tests and inspections.
 - 3. Prepare test and inspection reports in accordance with requirements listed in NFPA 2001, Section "Installation Acceptance."

3.8 CLEANING

- A. Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, using a suitable nonflammable cleaner. Pipe network shall be free of particulate matter and oil residue before installing nozzles or discharge devices.

3.9 OPERATIONAL CONDITION SYSTEM FILLING

- A. Preparation:
 - 1. Verify that clean-agent fire-extinguishing system and protected enclosure have passed all required tests and inspections in accordance with NFPA 2001.
 - 2. Verify that clean-agent fire-extinguishing piping system installation is completed and cleaned.
 - 3. Verify complete enclosure integrity.
 - 4. Verify operation of ventilation and exhaust systems.
- B. Filling Procedures:
 - 1. Fill clean-agent fire-extinguishing containers with extinguishing agent, and pressurize to indicated charging pressure.
 - 2. Install filled containers.
 - 3. Energize circuits.
 - 4. Adjust operating controls.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain clean-agent fire-extinguishing systems.

END OF SECTION 212200

SECTION 220500 – BASIC PIPING MATERIAL AND METHODS REQUIRMENTS

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. Grout.
 - 3. Silicone sealants.
 - 4. Escutcheons.
 - 5. Transition Couplings.
 - 6. Dielectric Fittings.
 - 7. Flexible Connectors.

1.3 SUBMITTALS

- A. Product Data: Submit for approval detailed product data such as model number, all relevant ratings, country of origin, interface details as necessary, covers and main supports. A specifications compliance sheet shall be provided for each product, indicating if the proposed product comply/does not comply with each article of the related specification section.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CALPICO, Inc.
 - 2. Metraflex Company (The).
 - 3. Thunderline/Link Seal.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, with plain ends and integral welded waterstop collar.
- D. Stack-sleeve fitting description: Manufactured, Dura-coated or galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.
- E. Mechanical sleeve seal description:
 - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.

2. Designed to form a hydrostatic seal of 20 psig minimum.
 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 4. Pressure Plates: Carbon steel.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.
- F. Sleeve seal fitting description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.
1. Plastic or rubber waterstop collar with center opening to match piping OD.

2.2 GROUT

- A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.3 SILICONE SEALANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. GE Construction Sealants; Momentive Performance Materials Inc.
 2. Permathane; ITW Polymer Sealants North America.
 3. Polymeric Systems, Inc.
 4. The Dow Chemical Company.
 5. Tremco Incorporated.
- B. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, Use NT.
- C. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.
- D. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

2.4 ESCUTCHEONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. BrassCraft Manufacturing Co.; a Masco company.
 2. Dearborn Brass.
 3. Jones Stephens Corp.

4. Keeney Manufacturing Company (The).
 5. Mid-America Fittings, Inc.
 6. ProFlo; a Ferguson Enterprises, Inc. brand.
- B. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.
- C. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.
- D. Split Floor Plates: Cast brass with concealed hinge.
- 2.5 TRANSITION COUPLINGS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Jay R. Smith Mfg Co; a division of Morris Group International.
 2. Romac Industries, Inc.
 3. Smith-Blair, a Xylem brand.
 4. Viking Johnson.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Unshielded, Nonpressure Transition Couplings:
1. Standard: ASTM C 1173.
 2. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 3. End Connections: Same size as and compatible with pipes to be joined.
 4. Sleeve Materials:
 - a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- D. Shielded, Nonpressure Transition Couplings:
1. Standard: ASTM C 1460.
 2. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 3. End Connections: Same size as and compatible with pipes to be joined.
- E. Pressure Transition Couplings:
1. Standard: AWWA C219.
 2. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 3. Center-Sleeve Material: Manufacturer's standard.
 4. Gasket Material: Natural or synthetic rubber.

5. Metal Component Finish: Corrosion-resistant coating or material.

2.6 DIELECTRIC FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Jomar Valve.
 2. Watts Water Technologies; a Watts company.
 3. Wilkins.
 4. Zurn Industries.
- B. Dielectric Unions:
 1. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 1. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
 1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.
- E. Dielectric Nipples:
 1. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple.
 - c. Pressure Rating: 300 psig at 225 deg F.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

2.7 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mason Industries, Inc.
 - 2. Mercer Rubber Co.
 - 3. Metraflex Co.
 - 4. Proco Products, Inc.
- B. Flexible Connectors: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections.
 - 1. Stainless-Steel-Hose, Flexible Connectors: For 2" and smaller, corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include ANSI 150# 304 stainless-steel nipples with screwed connections, welded to hose.
 - 2. Bronze Hose, Flexible Connectors: For 2" and smaller, corrugated bronze inner tubing covered with bronze wire braid. Include ANSI 150# brass nipples with screwed connections, braised to hose.
 - 3. Stainless-Steel-Hose, Flexible Connectors: For 2-1/2" and larger, corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include ANSI 150# 304 stainless-steel nipples or flanges, welded to hose.

PART 3 - EXECUTION

3.1 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 pipe sleeves, Steel pipe sleeves, or Sleeve-seal fittings.
 - 2. Exterior Concrete Walls below Grade and Concrete Slabs-on-Grade:
 - a. Cast-iron pipe sleeves with mechanical sleeve-seal system, Steel pipe sleeves with mechanical sleeve-seal system, or Sleeve-seal fittings.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs above Grade:
 - a. Steel pipe sleeves, PVC pipe sleeves, Stack-sleeve fittings, or Sleeve-seal fittings.
 - 1) Do not use PVC pipe sleeves when exposed to return air plenums.
 - 4. Interior Partitions:
 - a. Steel pipe sleeves or PVC pipe sleeves.
 - 1) Do not use PVC pipe sleeves when exposed to return air plenums.

3.2 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
 - 1. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.

- a. Sleeves are not required for core-drilled holes.
 - B. 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 above finished floor level.
 - 2. Using grout or silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
 - C. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.
 - D. Install stack-sleeve fittings in new slabs as slabs are constructed.
 - 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing.
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.
 - E. Install mechanical sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
 - 1. 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 mechanical 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.
 - F. Install sleeve-seal fittings in new walls and slabs as they are constructed.
 - 1. 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.
 - 2. Secure nailing flanges to concrete forms.
 - 3. Use grout or silicone sealant to seal the space around outside of sleeve-seal fittings.
 - G. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.
- 3.3 ESCUTCHEON AND FLOOR PLATE INSTALLATION
- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.

- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. One-piece or split-plate cast brass with polished, chrome-plated finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece or split floor plate.

3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Transition Couplings:
 - 1. Install transition couplings at joints of piping with small differences in ODs.
 - 2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
 - 3. In Aboveground Pressure Piping: Fitting-type transition couplings.
 - 4. In Underground Pressure Piping:
 - a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
 - b. NPS 2 and Larger: Pressure transition couplings.
- B. Dielectric Fittings:
 - 1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
 - 2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
 - 3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits.
 - 4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 FLEXIBLE CONNECTORS INSTALLATION

- A. Install flexible connectors for piping system connections on equipment side of shutoff valves for all Plumbing equipment, pumps, and where indicated on Drawings.
 - 1. Install stainless steel connectors for domestic water copper equipment connections 2" and smaller.
 - 2. Install bronze connectors for non-domestic water copper equipment connections 2" and smaller.
 - 3. Install flanged stainless steel connectors for flanged equipment connections 2-1/2" and larger.
- B. Install connectors according to manufacturer's recommendations.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
- C. Using new materials, replace broken and damaged escutcheons and floor plates.

D. Prepare test and inspection reports.

END OF SECTION 220500

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes general requirements for single-phase and 3-phase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

1.4 QUALITY ASSURANCE

- A. Comply with NEMA MG 1 unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 104 deg F and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.2 3-PHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.

- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.3 ADDITIONAL REQUIREMENTS FOR 3-PHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.4 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
- B. Service Factor: 1.0
- C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- D. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- E. Motors 1/20 HP and Smaller: Shaded-pole type.
- F. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Thermometers
 - 2. Thermowells.
 - 3. Dial-type pressure gauges.
 - 4. Gauge attachments.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 THERMOMETERS

- A. Standard: ASME B40.200.
- B. Case: Liquid-filled stainless steel and sealed, cast aluminum and sealed, or drawn steel and sealed.
- C. Case Form: Adjustable angle, back angle, straight.
- D. Element: Bourdon tube.
- E. Movement: Mechanical, with link to pressure element and connection to pointer.
- F. Tube: Glass with magnifying lens and blue or red organic liquid.
- G. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
- H. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
- I. Pointer: Dark-colored metal.
- J. Window: Plain glass or plastic.
- K. Ring: Metal or stainless steel.
- L. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
- M. Element: Bimetal coil.
- N. Connector Type(s): Union joint, adjustable angle rigid, back and rigid, bottom, with unified-inch or ASME B1.1 screw threads.
- O. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
- P. Accuracy: Plus or minus 1 percent of scale range.

2.2 THERMOWELLS

- A. Standard: ASME B40.200.

- B. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
- C. Material for Use with Copper Tubing: CNR or CUNI.
- D. Material for Use with Steel Piping: CRES or CSA.
- E. Type: Stepped shank unless straight or tapered shank is indicated.
- F. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
- G. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
- H. Bore: Diameter required to match thermometer bulb or stem.
- I. Insertion Length: Length required to match thermometer bulb or stem.
- J. Lagging Extension: Include on thermowells for insulated piping and tubing.
- K. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
- L. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAUGES

- A. Metal-Case, Dial-Type Pressure Gauges:
 - 1. Standard: ASME B40.100.
 - 2. Case: Liquid-filled sealed type(s); cast aluminum or drawn steel.
 - 3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 - 7. Pointer: Dark-colored metal.
 - 8. Window: Glass or plastic.
 - 9. Ring: Metal, brass, or stainless steel.
 - 10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAUGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, 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, ASME B1.20.1 pipe threads.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
- B. Install pressure gauges in the following locations:
 - 1. Building water service entrance into building.

2. Suction and discharge of each domestic water pump.

- C. Install thermowells with socket extending a minimum of 2 inches into fluid or one-third of pipe diameter for pipes 3" and smaller. Install in vertical position in piping tees.
- D. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- E. Install thermowells with extension on insulated piping.
- F. Fill thermowells with heat-transfer medium.
- G. Thermometer stems shall be of length to match thermowell insertion length.
- H. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- I. 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.
- J. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
- K. Install remote-mounted pressure gauges on panel.
- L. Install valve and snubber in piping for each pressure gauge for fluids.

3.2 CONNECTIONS

- A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

3.3 ADJUSTING

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

3.4 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Domestic Cold-Water Piping: 0 to 100 deg F.
- B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F.

3.5 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 160 psi.
- B. Scale Range for Domestic Water Piping: 0 to 160 psi.

END OF SECTION 220519

SECTION 220523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball Valves
2. Check Valves
3. Gate Valves

1.2 SUBMITTALS

A. Product Data: For each type of valve.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, weld ends, and soldered ends.
3. Set ball valves open to minimize exposure of functional surfaces.
4. Set gate valves closed to prevent rattling.
5. Set check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use operating handles, handwheels, or stems as lifting or rigging points unless specifically indicated for this purpose in manufacturer's instructions.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Standards:

1. Domestic water valves intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), requirements of authorities having jurisdiction, and NSF 61/NSF 372, or to be certified in compliance with NSF 61/NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

B. ASME Compliance:

1. ASME B1.20.1 for threads for threaded end valves.
2. ASME B16.1 for flanges on iron valves.
3. ASME B16.5 for flanges on steel valves.
4. ASME B31.9 for building services valves.

5. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
6. ASME B16.22 for wrought copper and copper alloy solder-joint connections.
7. ASME B16.34 for flanged and threaded end connections
- C. Provide bronze valves made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- D. AWWA Compliance: AWWA C606 for groove-end connections.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Bypass and Drain Connections: MSS SP-45.
- H. Valve Actuator Type:
 1. Ball Valve
 - a. Hand Lever: For quarter-turn valves NPS 6 and smaller.
- I. Valves in Insulated Piping:
 1. Provide 2-inch extended neck stems.
 2. Extended operating handles with nonthermal-conductive covering material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 3. Memory stops that are fully adjustable after insulation is applied.

2.2 BALL VALVES

- A. Bronze Ball Valves, Two piece:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Watts Water Technologies; a Watts company.
 - f. Zurn Industries, LLC.
 2. Standard: MSS SP-110; MSS SP-145.
 3. CWP Rating: 600 psig.
 4. Body Design: Two piece.
 5. Body Material: Bronze.
 6. Ends: Threaded or soldered.
 7. Seats: PTFE.
 8. Stem: Bronze or brass.
 9. Ball: Chrome-plated brass.

10. Port: Full.

B. Cast Iron Ball Valves, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Watts Water Technologies; a Watts company.
 - c. Zurn Industries, LLC.
2. Standard: MSS SP-72; MSS SP-110; MSS SP-145.
3. CWP Rating: 200 psig.
4. Body Design: Split body.
5. Body Material: ASTM A126, gray iron.
6. Ends: Flanged or threaded.
7. Seats: PTFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel.
10. Port: Full.

2.3 CHECK VALVES

A. Bronze, Lift Check Valves with Nonmetallic Disc, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hammond.
 - b. Nibco.
2. Standard: MSS SP-80, Type 2.
3. CWP Rating: 200 psig.
4. Body Design: Vertical flow.
5. Body Material: ASTM B61 or ASTM B62, bronze.
6. Ends: Threaded or soldered. See valve schedule articles.
7. Disc: "Teflon."

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Milwaukee.
 - c. Nibco.
2. Standard: MSS SP-80, Type 3.
3. CWP Rating: 200 psig.

4. Body Design: Horizontal flow.
5. Body Material: ASTM B62, bronze.
6. Ends: Threaded or soldered. See valve schedule articles.
7. Disc: Bronze.

C. Iron, Swing Check Valves with Metal Seats, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond.
 - c. Milwaukee.
 - d. Nibco.
 - e. Watts Water Technologies; a Watts company.
 - f. Zurn Industries, LLC.
2. Standard: MSS SP-71, Type I.
3. CWP Rating: 200 psig.
4. Body Design: Clear or full waterway.
5. Body Material: ASTM A126, gray iron with bolted bonnet.
6. Ends: Flange or threaded. See valve schedule articles.
7. Trim: Bronze.
8. Gasket: Asbestos free.

2.4 GATE VALVES

A. Bronze Gate Valves, NRS, Class 125:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond.
 - c. Milwaukee.
 - d. Nibco.
2. Standard: MSS SP-80, Type 1.
3. CWP Rating: 200 psig.
4. Body Material: Bronze with integral seat and screw-in bonnet.
5. Ends: Threaded or solder joint.
6. Stem: Bronze.
7. Disc: Solid wedge; bronze.
8. Packing: Asbestos free.

9. Handwheel: Malleable iron, bronze, or aluminum.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves; a part of Aalberts Integrated Piping Systems.
 - b. Hammond.
 - c. Milwaukee.
 - d. Nibco.
2. Standard: MSS SP-70, Type I.
3. CWP Rating: 200 psig.
4. Body Material: Gray iron with bolted bonnet.
5. Ends: Flange.
6. Trim: Bronze.
7. Disc: Solid wedge.
8. Packing and Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, provide the same types of valves with higher CWP ratings.
- B. Pump Discharge
 1. Shutoff Valves:
 - a. Install shutoff valve on each sewage pump discharge.
 - b. Install gate or full-port ball valve for piping NPS 2 and smaller.
 - c. Install gate valve for piping NPS 2-1/2 and larger.
 2. Check Valves:
 - a. Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
 - b. NPS 2 and Smaller: Bronze, swing check valves with nonmetallic disc.
 - c. NPS 2-1/2 and Larger for Domestic Water: Iron, swing check valves with lever and weight or spring; or iron, center-guided, metal-seat check valves.
 - d. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron, swing check valves with lever and weight or spring.

3.2 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Ball Valves
 1. Pipe NPS 2 and Smaller:
 - a. Bronze ball valves with solder-joint valve-end.

2. Pipe NPS 2-1/2 and Larger:
 - a. Cast Iron ball valves, Class 125 with flanged ends.

B. Check Valves

1. Pipe NPS 2 and Smaller:
 - a. Bronze, swing check valves with bronze disc, Class 125, with soldered end connections.
 - b. Bronze, lift check valves with nonmetallic disc, Class 125, with soldered connections.
2. Pipe NPS 2-1/2 and Larger:
 - a. Iron, swing check valves with metal seats, Class 125, with flange end connections.

C. Gate Valves

1. Pipe NPS 2 and Smaller:
 - a. Bronze gate valves, NRS, Class 125 with soldered ends.
2. Pipe NPS 2-1/2 and Larger:
 - a. Iron gate valves, OS&Y, Class 125 with flange ends.

3.3 EXAMINATION

- A. Do not attempt to repair defective valves; replace with new valves. Remove defective valves from site.

3.4 INSTALLATION OF VALVES

- A. Install valves with unions or flanges at each piece of equipment arranged to allow space for service, maintenance, and equipment removal without system shutdown.
- B. Provide support to piping adjacent to valves such that no force is imposed upon valves.
- C. Locate valves for easy access and where not blocked by equipment, other piping, or building components.
- D. Install valves in position that does not project into aisles or block access to other equipment.
- E. For valves in horizontal piping, install valves with stem at or above center of pipe.
- F. Install valves in position to allow full valve actuation movement.
- G. Install valves in position to allow full stem and manual operator movement.
- H. Verify that joints of each valve have been properly installed and sealed to assure there is no leakage or damage.
- I. Adhere to manufacturer's written installation instructions. When soldering or brazing valves, do not heat valves above maximum permitted temperature. Do not use solder with melting point temperature above valve manufacturer's recommended maximum.

3.5 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service, but before final adjusting and balancing. Replace valves exhibiting leakage.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipe hangers and supports

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.
- C. Regulatory Requirements: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.
- D. All materials shall be new and manufactured for the specific purpose of supporting systems, equipment, pipes, and accessories.

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Armacell.
 - 2. Anvil International.
 - 3. Cooper B-Line, Inc.
 - 4. Halfen-DEHA.
 - 5. Hilti.
 - 6. ERICO\Michigan Hanger Co.
 - 7. National Pipe Hanger Corporation.
 - 8. Phillips

9. Power-Strut.
 10. Rooftop Blox.
 11. Unistrut.
- B. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.
1. Components shall have galvanized coatings where installed for piping and equipment that will not have factory applied or field-applied finish.
 2. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
 3. Components as listed below shall be made of 304 stainless steel where installed in corrosive environments and/or where indicated on the drawings.
- C. Thermal-hanger shield inserts
1. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.
 2. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi ASTM C552, Type II cellular glass with 100-psi, or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
 3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
 4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
 5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.
- D. Pipe stands
1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
 2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 4. Hardware: Galvanized steel or polycarbonate.
 5. Accessories: Protection pads.
- E. Manufacturer Metal Framing Systems:
1. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
 2. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
 3. Channels: Continuous slotted carbon-steel, stainless-steel, Type 304 stainless-steel, or Type 316 extruded-aluminum channel with intumed lips.
 4. Channel Width: Selected for applicable load criteria.

5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
- F. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
1. Indoor Applications: Zinc-coated or stainless steel.
 2. Outdoor Applications: Stainless steel.
- G. Pipe-Positioning Systems
1. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

PART 3 - EXECUTION

3.1 APPLICATION

- A. 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 PIPE HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 2. Field fabricate from ASTM A36/A36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. 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. Insulated Piping:
1. Attach clamps and spacers to piping.
 - a. Use thermal hanger-shield insert with clamp sized to match OD of insert.
 - b. 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.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.
 - F. Fastener System Installation:
 1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
 - G. Pipe Stand Installation:
 1. Pipe Stand Types, except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.
 - H. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
 - I. Install hangers and supports to allow controlled thermal 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.
 - J. Install lateral bracing with pipe hangers and supports to prevent swaying.
 - K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
 - L. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
 - M. 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 METAL FABRICATIONS
- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.
 - B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
 - C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 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.

3.5 PAINTING

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

END OF SECTION 220529

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.2 SUBMITTALS

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

1.3 SPARE PARTS

- A. Furnish minimum of 5% extra stock of each plumbing identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.
1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

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

- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- F. Fasteners: Stainless steel rivets or self-tapping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

- A. Material: Vinyl.
- B. Minimum Thickness: 0.005 inch.
- C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.
- D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.
- E. Maximum Temperature: 160 deg F.
- F. Minimum Width: 4 inches.

2.4 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.5 STENCILS

A. Stencils for Piping:

1. Lettering Size: Size letters in accordance with ASME A13.1 for piping.
2. Stencil Material: Aluminum, brass, or fiberboard.
3. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
4. Identification Paint: Exterior, alkyd enamel or acrylic enamel in colors in accordance with ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
5. Letter and Background Color: As indicated for specific application under Part 3.

2.6 VALVE TAGS

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

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

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

C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

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

2.7 WARNING TAGS

A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Letter and Background Color: As indicated for specific application under Part 3.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.2 INSTALLATION

- A. Permanently fasten labels on each item of plumbing equipment including:
 - 1. Vacuum breakers.
 - 2. Backflow preventers.
 - 3. Automatic water shutoff valve systems.
 - 4. Balancing valves.
 - 5. Temperature-actuated, water mixing valves.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
- C. Locate equipment labels where accessible and visible.
- D. Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.
- E. Use warning tapes or detectable warning tape over ferrous piping.
- F. Use detectable warning tape over nonferrous piping and over edges of underground structures.
- G. Install warning tape on pipes with cross-designated walkways providing less than 6 ft. of clearance.
- H. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.
- I. Locate tape to be readily visible from the point of normal approach.
- J. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- K. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- L. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. of each valve and control device.
 - 2. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 3. Within 3 ft. of equipment items and other points of origination and termination.

4. Spaced at maximum intervals of 50 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping and equipment.
 - M. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
 - N. Flow-Direction Flow Arrows: Use arrows, in compliance with ASME A13.1, to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
 - O. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, faucets, convenience and lawn-watering hose connections, and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.
 1. Valve-Tag Size and Shape: 2 inches, round or square.
 - P. Attach warning tags, with proper message, to equipment and other items where indicated on Drawings.
 - Q. Colors
 1. Domestic Water Piping: White letters, safety-green background.
 2. Sanitary Waste and Storm Drainage Piping: White letters, black background.
 3. Nonpotable Water: Black letters, safety-yellow background.
 4. Warning Tape: Yellow background with black diagonal stripes.
 5. Warning Tag: Black letters, safety-yellow background
- 3.3 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.

END OF SECTION 220553

SECTION 220700 – PLUMBING PIPE AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following plumbing piping services:

- 1. Plumbing piping

1.2 SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. The packaging is to include name of the manufacturer, fabricator, type, description, and size.

1.4 COORDINATION

- A. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.5 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than ten years of documented experience.
- B. Contractor / Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum five years of experience.
- C. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84 or UL723, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
 - 1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. All Insulation Installed Outdoors; Flame-spread index of 75 or less, and smoke-developed index of 150 or less.
- D. Products that come into contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- E. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- F. Insulations shall not contain formaldehyde, asbestos, lead, mercury, mercury compounds, or polybrominated diphenyl ether fire retardants.

- G. Fiberglass insulations shall be constructed of bio-soluble fiber.
- H. Fiberglass insulations shall have a minimum of 50 percent recycled glass content; certified and validated in accordance with UL 2809 Environmental Claim Validation Procedure for Recycled Content.
- I. Fiberglass insulations shall have a bio-based, formaldehyde-free binder and be UL GREENGUARD Gold certified.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Fiberglass Preformed Pipe Insulation: Glass fibers bonded with a bio-based thermosetting resin, complying with ASTM C547, Type I and IV; ASTM C585, ASTM C411, ASTM C795. One piece, mandrel wound construction with factory pre-slit sidewall. Provide with factory applied white ASJ SSL or white ASJ+ SSL+ vapor retarder jacket with self-sealing lap closure and butt strips, complying with ASTM C1136. Maximum service temperature of 1,000 degrees F. Thermal conductivity (k-value) at 75 degrees F mean temperature shall be 0.23 Btu x in. /h x sq. ft. x degrees F, or less. Maximum Flame spread rating of 25 and Smoke developed rating of 50 when tested in accordance with ASTM E84 or UL 723. Must be NFPA 90A and 90B compliant, UL Environment GREENGUARD Gold certified, UL Validated Formaldehyde-free, UL Validated for Recycled Glass Content of 50% minimum, bio-soluble certified by EUCB, and UL Listed as Plenum Rated for installation over polymer pipes in plenums.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - d. Owens Corning.
 - 2. Fabricated shapes in accordance with ASTM C450 and ASTM C585.
 - 3. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- B. Glass-Fiber Blanket: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 450 deg F in accordance with ASTM C411). Comply with ASTM C553, Type II, and ASTM C1290, Type II, with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Certainteed; SAINT-GOBAIN.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Owens Corning.

2.2 INSULATING CEMENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ramco Insulation / Thermocoat.

- B. Glass-Fiber Insulating Cement: Comply with ASTM C195.
- C. Glass-Fiber Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

2.3 ADHESIVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Products / H.B. Fuller Construction Products.
 - 2. Foster Products / H.B. Fuller Construction Products.
 - 3. Vimasco Corporation.
 - 4. Mon-Eco Industries
- B. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- C. Glass-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ and ASJ+ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A, for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS AND COATINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Products / H.B. Fuller Construction Products.
 - 2. Foster Products / H.B. Fuller Construction Products.
 - 3. Vimasco Corporation.
 - 4. Mon-Eco Industries
- B. Materials are compatible with insulation materials, jackets, and substrates.
- C. Vapor-Retarder Mastic, Water Based: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: 0 to plus 180 deg F.
 - 3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
- D. Vapor-Retarder Mastic, Solvent Based, Indoor Use: Suitable for indoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: 0 to 180 deg F.
- E. Vapor-Retarder Mastic, Solvent Based, Outdoor Use: Suitable for outdoor use on below-ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM E96/E96M or ASTM F1249.
 - 2. Service Temperature Range: Minus 50 to plus 220 deg F.

2.5 LAGGING ADHESIVES

- A. Adhesives comply with MIL-A-3316C, Class I, Grade A, and are compatible with insulation materials, jackets, and substrates.
 - 1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 - 2. Service Temperature Range: 0 to plus 180 deg F.

2.6 SEALANTS

- A. Materials are as recommended by the insulation manufacturer and are compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 58 to plus 176 deg F.
- C. ASJ and ASJ+ Flashing Sealants and PVC Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 40 to plus 250 deg F.

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ+-SSL+: ASJ+ jacket with Self-Sealing Advanced Closure System; complying with ASTM C 1136 Type I, II, III, IV, VII, VIII, and X secured with self-sealing longitudinal laps and matching ASJ+ butt wraps.
 - 2. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C 1136 Type I, II, III, IV, VII, VIII, and X.
 - 3. ASJ: White, kraft paper, fiberglass reinforced scrim with aluminum foil backing; complying with ASTM C 1136, Type I.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied, protective finish jackets comply with ASTM C1136, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 - 1. Adhesive: As recommended by jacket material manufacturer.
 - 2. Color: White.
 - 3. Factory fabricated tank heads and tank side panels.
 - 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.

C. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
2. Stainless Steel Jacket: ASTM A 167 or ASTM A 240/A 240M..
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
 - d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

D. Factory-Fabricated Fitting Covers: Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

1. Same material, finish, and thickness as jacket.
2. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3. Tee covers.
4. Flange and union covers.
5. End caps.
6. Beveled collars.
7. Valve covers.

E. Self-Adhesive Outdoor Jacket (Asphaltic): 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with aluminum-foil facing.

F. Self-Adhesive Indoor/Outdoor Jacket (Non-Asphaltic): Vapor barrier and waterproofing jacket for installation over insulation located aboveground outdoors or indoors. Specialized jacket with five layers of laminated aluminum and polyester film with low-temperature acrylic pressure-sensitive adhesive. Outer aluminum surface is coated with UV-resistant coating for protection from environmental contaminants.

1. Permeance: 0.00 perm as tested in accordance with ASTM F1249.
2. Flamespread/Smoke Developed: 25/50 as tested in accordance with ASTM E84.
3. Aluminum Finish

2.9 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Mesh: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in. for covering pipe and pipe fittings.
- B. Woven Polyester Mesh: Approximately 1 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. in., in a Leno weave, for pipe.

2.10 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Cloth: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd..

2.11 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.
 - 1. Width: 3 inches.
 - 2. Thickness: 11.5 mils.
 - 3. Adhesion: 90 ounces force/inch in width.
 - 4. Elongation: 2 percent.
 - 5. Tensile Strength: 40 lbf/inch in width.
 - 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 - 1. Width: 2 inches.
 - 2. Thickness: 6 mils.
 - 3. Adhesion: 64 ounces force/inch in width.
 - 4. Elongation: 500 percent.
 - 5. Tensile Strength: 18 lbf/inch in width.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 - 1. Width: 2 inches.
 - 2. Thickness: 3.7 mils.
 - 3. Adhesion: 100 ounces force/inch in width.
 - 4. Elongation: 5 percent.
 - 5. Tensile Strength: 34 lbf/inch in width.

2.12 SECUREMENTS

- A. Bands:
 - 1. Stainless Steel: ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
 - 2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.

- B. Wire: 0.080-inch nickel-copper alloy, 0.062-inch soft-annealed, stainless steel, or 0.062-inch soft-annealed, galvanized steel.

PART 3 - EXECUTION

3.1 PIPING INSULATION SCHEDULE

- A. Omit insulation on the following:
 - 1. Chrome-plated exposed piping
 - 2. Water Hammer Arrestors
 - 3. Balancing and flow valves
 - 4. Drain lines from water coolers
 - 5. Drainage piping located in crawl spaces or tunnels
 - 6. Exterior condensate drain piping
 - 7. Buried piping
 - 8. Pre-insulated equipment
 - 9. Exposed storm drainage piping in parking structures
- B. Insulate the following piping systems with one of the following types and thickness of insulation:
 - 1. Domestic Cold Water:
 - a. NPS 3/4" and Smaller:
 - 1) Glass Fiber, Preformed Pipe Insulation, Type I: 1/2" thick
 - b. NPS 1" to 6":
 - 1) Glass Fiber, Preformed Pipe Insulation, Type I: 1" thick.
 - 2. Domestic Hot and Recirculated Hot Water:
 - a. NPS 1-1/4" and Smaller:
 - 1) Glass Fiber, Preformed Pipe Insulation, Type I: 1" thick.
 - b. NPS 1-1/2" and Larger:
 - 1) Glass Fiber, Preformed Pipe Insulation, Type I: 2" thick.
 - 3. Stormwater and Overflow:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1" thick.
 - 4. Roof Drain and Overflow Drain Bodies:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1" thick.
 - 5. Condensate piping:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2" thick.
 - 6. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:
 - a. Glass-Fiber, Preformed Pipe Insulation, Type I: 1/2" thick.
- C. Insulate the following plumbing equipment:

1. Hot Water Pumps
 - a. Glass-Fiber Blanket: 2" thick.

3.2 JACKET SCHEDULE

- A. Provide jackets on insulation for the following systems:
 1. Piping, Exposed:
 - a. PVC: 20 mils thick. or
 - b. Painted Aluminum, Smooth or Corrugated with Z-Shaped Locking Seam: 0.024 inch thick.

3.3 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 PREPARATION

- A. Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range of between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the tradesman installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.5 GENERAL INSTALLATION REQUIREMENTS

- A. To ensure that it will achieve its highest possible performance and serve its intended purpose, install all mechanical insulation materials and accessories in accordance with manufacturer's published instructions (latest edition) and industry practices detailed by the North American Commercial and Industrial Insulation Standards Manual (latest edition). Published by Midwest Insulation Contractors Associations (www.micainsulation.org).
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping, including fittings, valves, and specialties.
- C. Install insulation materials, forms, vapor barriers or retarders, jackets, and of thicknesses required for each item of equipment and pipe system, as specified in insulation system schedules.
- D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

- E. Install insulation with longitudinal seams at top and bottom (12 o'clock and 6 o'clock positions) of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents, unless otherwise approved by the engineer-of-record.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Cut insulation in a manner to avoid compressing insulation.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.6 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
- 3.7 GENERAL PIPE INSULATION INSTALLATION
- A. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered or routed fittings made from same material and density as that of adjacent pipe insulation. Each piece is butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as that used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as that used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers, so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges, mechanical couplings, and unions, using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than 2 times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Stencil or label the outside insulation jacket of each union with the word "union" matching size and color of pipe labels.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket, except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing, using PVC tape.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation conforms to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as that of adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union at least 2 times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

E. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap
4. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

3.8 GENERAL EQUIPMENT INSULATION INSTALLATION

A. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a field-adjustable latching mechanism.
2. Fabricate boxes from galvanized steel, at least 0.040 inch thick.
3. For below-ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.9 INSTALLATION OF GLASS-FIBER

A. Insulation Installation on Straight Pipes and Tubes:

1. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant. Provide vapor dam every 12 feet of straight run of pipe.

B. Insulation Installation on Pipe Flanges:

1. Install prefabricated pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with glass-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.

2. When prefabricated insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install prefabricated sections of same material as that of straight segments of pipe insulation when available.
2. When prefabricated sections are not available, install fabricated sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.10 INSTALLATION OF FIELD-APPLIED JACKETS

- A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
 1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
 2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
 3. Completely encapsulate insulation with coating, leaving no exposed insulation.
- B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.
 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless steel bands 12 inches o.c. and at end joints.

3.11 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system as directed by architect.
 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. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless steel jackets.

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. PVC pipe and fittings.
 3. Piping joining materials.
 4. Specialty pipe fittings

1.3 SUBMITTALS

- A. General: Submit for approval, manufacturers' technical literature, shop and construction drawings and other submittals required by the Specification. These documents shall be provided prior to ordering equipment and executing any related work on site.
- B. Product Data: Submit for approval detailed product data such as model number, all relevant ratings, country of origin, interface details as necessary, covers and main supports. A specifications compliance sheet shall be provided for each product, indicating if the proposed product comply/does not comply with each article of the related specification section.
- C. Coordination Drawings: Piping layout, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Potable-water piping and components shall comply with NSF 14, NSF 61, and NSF 372.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B88, Type L.
- B. Annealed-Temper Copper Tube: ASTM B88, Type K.
- C. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, pressure fittings.

2.3 PVC PIPE AND FITTINGS

- A. PVC Pipe: ASTM D1785, with wall thickness as indicated in "Piping Applications" Article.
- B. PVC Socket Fittings: ASTM D2467 for Schedule 80.
- C. Solvent Cements for Joining PVC Piping: ASTM D2564. Include primer according to ASTM F656.

2.4 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials:
 1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.

- 2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B32, lead-free alloys.
- D. Flux: ASTM B813, 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.

2.5 SPECIALTY PIPE FITTINGS

- A. Transition Couplings: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined. Comply with requirements for transition fittings specified in 220500 "Basic Piping Materials and Methods Requirements."
- B. Dielectric Fittings: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined. Comply with requirements for dielectric fittings specified in 220500 "Basic Piping Materials and Methods Requirements."

PART 3 - EXECUTION

3.1 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Under-building-slab, domestic water, building-service piping NPS 3 and smaller, shall be PVC, Schedule 80; socket fittings; and solvent-cemented joints.
- D. Aboveground, domestic water piping shall be drawn-temper copper tube, ASTM B88, Type L; wrought-copper, solder-joint fittings; and soldered joints.

3.2 INSTALLATION OF PIPING

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install valves according to section 220523 "General Duty Valves for Plumbing Piping."
- E. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- F. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

- G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
 - H. Install piping to permit valve servicing.
 - I. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
 - J. Install piping free of sags and bends.
 - K. Install fittings for changes in direction and branch connections.
 - L. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
 - M. Install pressure gauges on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gauges in Section 220519 "Meters and Gages for Plumbing Piping."
 - N. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Basic Piping Materials and Methods Requirements."
 - O. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Basic Piping Materials and Methods Requirements."
 - P. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- 3.3 JOINT CONSTRUCTION
- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
 - C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 - D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
 - E. Soldered Joints for Copper Tubing: Apply ASTM B813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B828 or CDA's "Copper Tube Handbook."
 - F. Joint Construction for Grooved-End Copper Tubing: Make joints according to AWWA C606. Roll groove ends of tubes. Lubricate and install gasket over ends of tubes or tube and fitting. Install coupling housing sections over gasket with keys seated in tubing grooves. Install and tighten housing bolts.
 - G. 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 SPECIALTY PIPE FITTING INSTALLATION

- A. Comply with requirements for installation of transition couplings and dielectric fittings specified in 220500 "Basic Piping Materials and Methods Requirements."

3.5 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements for hangers, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Support horizontal piping within 12 inches of each fitting.
- C. Install hangers for copper piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- D. Support vertical runs of copper piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. 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 or dielectric fitting to join dissimilar piping materials.

3.7 IDENTIFICATION

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

3.8 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.
 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.
 - c. Adjust thermostatic balancing valves to temperatures 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.

3.9 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.
 - 3) Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - 4) Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

2. Piping Tests:

- a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
- b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
- c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
- d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
- e. Hydrostatic testing and documentation of test results for polypropylene piping to be in accordance with the manufacturer's instructions and submitted to the manufacturer upon successful completion per warranty requirements.
- f. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
- g. 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 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 system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until chlorine level is reduced to that of the incoming city water.
 - 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.
- E. Place plugs in end of uncompleted piping at end of each day or when work stops.
- END OF SECTION 221116

SECTION 221117 - GRAY-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. Under-building-slab and aboveground gray-water pipes, tubes, and fittings inside buildings.
 - 2. Encasement for piping.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Pipes, tubes, fittings, and specialties for each type of piping.
 - 2. Joining materials.
 - 3. Encasement for piping.
 - 4. Transition fittings.
 - 5. Dielectric fittings.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
- B. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- C. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- D. 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.

2.2 PVC WATER PIPE AND FITTINGS

- A. PVC Water Pipe: ASTM D 1785, Schedule 40 purple in color.
- B. PVC Water Socket Fittings: ASTM D 2466 for Schedule 40 purple in color.
- C. PVC Water Schedule 80 Threaded Fittings: ASTM D 2464.

2.3 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials:

1. AWWA C110/A21.10, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free unless otherwise indicated.
2. Full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys.
- D. Flux: ASTM B 813, water flushable.
- E. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
- F. Plastic, Pipe-Flange Gaskets, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.4 TRANSITION FITTINGS

- A. Transition Couplings: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined. Comply with requirements for transition fittings specified in 220500 "Basic Piping Materials and Methods Requirements."
- B. Dielectric Fittings: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined. Comply with requirements for dielectric fittings specified in 220500 "Basic Piping Materials and Methods Requirements."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for gray-water piping to verify actual locations of piping connections before equipment or fixture installation.

3.2 GRAY-WATER 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. Underground, gray-water piping, NPS 3 and smaller, shall be the following:
 1. PVC, Schedule 40 Schedule 80; socket fittings; and solvent-cemented joints.
- D. Aboveground gray-water piping, NPS 2 and smaller, shall be the following:
 1. Hard copper tube, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and soldered joints.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of gray-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 underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
- D. Install piping concealed from view and protected from physical contact by building occupants 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, and coordinate with other services occupying that space.
- G. Install piping to permit valve servicing.
- H. 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.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- L. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220500 "Basic Piping Materials and Methods Requirements."
- M. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220500 "Basic Piping Materials and Methods Requirements."
- N. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- O. 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."
- P. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve inside the building at each gray-water 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."
- Q. Install shutoff valve immediately upstream of each dielectric fitting.
- R. Install gray-water water piping level and plumb.
- S. Install pressure gages on suction and discharge piping for each plumbing pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."
- T. Comply with requirements for pipe hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Soldered Joints for Copper Tubing: Apply ASTM 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."
- E. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for gray-water water service. Join flanges with gasket and bolts according to ASME B31.9.
- F. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.5 SPECIALTY PIPE FITTING INSTALLATION

- A. Comply with requirements for installation of transition couplings and dielectric fittings specified in 220500 "Basic Piping Materials and Methods Requirements."

3.6 INSTALLATION OF HANGERS AND SUPPORTS

- 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, supports, and anchor devices in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. 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 and coupling.
- 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 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.

- C. Label all non-potable water piping "NON-POTABLE, DO NOT DRINK."

3.8 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. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
 4. Remove and clean strainer screens. Close drain valves and replace drain plugs.
 5. Check plumbing specialties and verify proper settings, adjustments, and operation.

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 "Water Piping Tests" Subparagraph 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. Water Piping Tests:
 - a. Fill gray-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 gray-water water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

- e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
- B. Gray-water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 221117

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Backflow preventers.
 - 2. Balancing valves.
 - 3. Temperature-actuated, water mixing valves.
 - 4. Strainers for domestic water piping.
 - 5. Drain valves.
 - 6. Water-hammer arresters.
 - 7. Flexible connectors.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Test and inspection reports.
- C. Field quality-control reports.
- D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Domestic water piping specialties intended to convey or dispense water for human consumption are to comply with the SDWA, requirements of authorities having jurisdiction, and NSF 61 and NSF 372, or to be certified in compliance with NSF 61 and NSF 372 by an American National Standards Institute (ANSI)-accredited third-party certification body that the weighted average lead content at wetted surfaces is less than or equal to 0.25 percent.

2.2 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: [**125 psig**] <Insert value> unless otherwise indicated.

2.3 BACKFLOW PREVENTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ames Fire & Waterworks; A WATTS Brand.
 - 2. WATTS.
 - 3. Zurn Industries, LLC.
- B. Reduced Pressure Zone Backflow Preventers: Meeting ASSE 1013, threaded end connections for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.
- C. Double-Check, Backflow-Prevention Assemblies: Meeting ASSE 1015, threaded end connection for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.

- D. Carbonated Beverage Dispenser, Dual-Check-Valve Backflow Preventers: Meeting ASSE 1032 threaded end connections.

2.4 BALANCING VALVES

A. Mechanical Temperature-Actuated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Caleffi North America.
 - b. Circuit Solver, a ThermOmegaTech Division
 - c. Recircsetter, Jomar Valve.
2. Pressure Rating: 200-psig maximum CWP.
3. Size: NPS 2 or smaller.
4. Body: Stainless steel or brass.
5. End Connections: Threaded or solder joint.

2.5 MIXING VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Leonard Valve Company.
 2. POWERS; A WATTS Brand.
- B. Point of Use Thermostatic Mixing Valve: Meeting ASSE 1070.
- C. Master Thermostatic Mixing Valves: Meeting ASSE 1017.
- D. Digital Master Thermostatic Mixing Valve Assemblies: Meeting ASSE 1017.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Machine Works.
 - b. Metraflex Co.
 - c. WATTS.
 - d. Zurn Industries, LLC.
2. Pressure Rating: 125 psig minimum unless otherwise indicated.
3. Body: Bronze for NPS 2 and smaller; cast iron for NPS 2-1/2 and larger.
4. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
5. Screen: Stainless steel with round perforations unless otherwise indicated.
6. Perforation Size: 0.062" for strainers 4" and smaller; 0.125" for strainers 5" and larger.
7. Drain: Pipe plug.

2.7 DRAIN VALVES

A. Ball-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.8 WATER-HAMMER ARRESTERS

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

1. AMTROL, Inc.
2. Josam Company.
3. Precision Plumbing Products.
4. Sioux Chief Manufacturing Company, Inc.
5. WATTS.
6. Zurn Industries, LLC.

B. Water-Hammer Arresters: Meeting ASSE 1010 or PDI-WH 201; piston type; sized per ASSE 1010, sizes AA and A through F, or PDI-WH 201, Sizes A through F.

2.9 FLEXIBLE CONNECTORS

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

1. Flex-Hose Co., Inc.
2. Mason Industries, Inc.
3. Metraflex Company (The).

B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.

1. Working-Pressure Rating: Minimum 250 psig.
2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPING SPECIALTIES

- A. Backflow Preventers: Install in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe-to-floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are unacceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- B. Balancing Valves: Install in locations where they can easily be adjusted. Set at indicated design flow rates.
- C. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- D. Y-Pattern Strainers: For water, install on supply side of each solenoid valve and pump.
- E. Water-Hammer Arresters: Install in water piping in accordance with PDI-WH 201.
 - 1. Air chambers shall not be used for controlling water hammer.

3.2 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.

3.3 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

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.
- D. Adjust each pressure vacuum breaker, reduced-pressure-principle backflow preventer, and double-check, backflow-prevention assembly in accordance with manufacturer's written instructions, authorities having jurisdiction and the device's reference standard.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections.
 - 1. Test each pressure vacuum breaker, reduced-pressure-principle backflow preventer, and double-check, backflow-prevention assembly according to authorities having jurisdiction and the device's reference standard.

2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 3. Operational Test: After electrical circuitry has been energized, start units to confirm unit operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.
- END OF SECTION 221119

SECTION 221123 – DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. In-line, sealless centrifugal pumps.
 - 2. Multiplex, variable-speed booster pumps.

1.2 SUBMITTALS

- A. Product Data: For each type of product, include construction materials; construction details; dimensions of individual components and profiles; rated capacities; certified performance curves with operating points plotted on curves; operating characteristics; electrical characteristics; and furnished specialties and accessories.
- B. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Retain protective coatings and flange's protective covers during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written instructions for handling.

1.4 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.5 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: UL 778 for motor-operated water pumps.
- C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.

PART 2 - PRODUCTS

2.1 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bell & Gossett, a Xylem Brand.
 - 2. Grundfos Pumps Corporation.
 - 3. Taco Comfort Solutions.
- C. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Minimum Working Pressure: 125 psig.
3. Maximum Continuous Operating Temperature: 220 deg F.
4. Casing: Bronze, with threaded or companion-flange connections.
5. Impeller: Composite or stainless steel.

2.2 MULTIPLEX, VARIABLE-SPEED BOOSTER PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Armstrong Fluid Technology.
 2. Bell & Gossett; a Xylem brand.
 3. Goulds Water Technology; a Xylem brand.
 4. Grundfos Pumps Corporation.
 5. Patterson Pump Company; a Gorman-Rupp company.
 6. QuantumFlo, Inc.
- B. Description: Factory-assembled and -tested, fluid-handling system for domestic water, with pumps, piping, valves, specialties, and controls, and mounted on base.
- C. Pumps:
 1. Type: End suction as defined in HI 1.1-1.2 and HI 1.3 for end-suction, close-coupled, single-stage, overhung-impeller, centrifugal pump.
 2. Casing: Radially split; bronze.
 3. Impeller: Closed, ASTM B584 cast bronze; statically and dynamically balanced and keyed to shaft.
 4. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve and deflector.
 5. Seal: Mechanical.
 6. Orientation: Mounted horizontally.
- D. Pumps:
 1. Type: Vertical, multistage as defined in HI 1.1-1.2 and HI 1.3 for in-line, multistage, separately coupled, overhung-impeller, centrifugal pump.
 2. Casing: Cast-iron or steel base and stainless-steel chamber.
 3. Impeller: Closed, stainless steel; statically and dynamically balanced and keyed to shaft.
 4. Shaft: Stainless steel.
 5. Seal: Mechanical.
 6. Bearing: Water-lubricated sleeve type.
- E. Motors: Single speed, with grease-lubricated, ball-bearings. Select motors that will not overload through full range of pump performance curve.

- F. Piping: Stainless-steel pipe and fittings.
- G. Valves:
 - 1. Shutoff Valves NPS 2 and Smaller: Gate valve or two-piece, full-port ball valve, in each pump's suction and discharge piping.
 - 2. Check Valves NPS 2 and Smaller: Silent or swing type in each pump's discharge piping.
 - 3. Thermal-Relief Valve: Temperature-and-pressure relief type in pump's discharge header piping.
- H. Dielectric Fittings: With insulating material to isolate joined dissimilar metals.
- I. VFC: Serving each pump in pump array.
 - 1. Manufactured Units: Pulse-width modulated inverter.
 - 2. Output Rating: Three phase; 1 to 66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
 - 3. Unit Operating Requirements:
 - a. Internal Adjustability:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: 0.1 to 999.9 seconds.
 - 4) Deceleration: 0.1 to 999.9 seconds.
 - 5) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - b. Self-Protection and Reliability Features:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.
 - 3) Under- and overvoltage trips.
 - 4) VFC and motor overload/overtemperature protection.
 - 5) Critical frequency rejection.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Motor-overtemperature fault.
 - c. Bidirectional autospeed search.
 - d. Torque boost.
 - e. Motor temperature compensation at slow speeds.
 - 1) Panel-mounted operator station.
 - 2) Historical logging information and displays.
 - 3) Digital indicating devices.
 - f. Control Signal Interface: Electric.
 - g. Proportional Integral Derivative (PID) control interface.

- h. DDC System for HVAC Protocols for Network Communications: ASHRAE 135.
- 4. Line Conditioning:
 - a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.
- 5. Instrumentation: Suction and discharge pressure gauges.
- 6. Lights: Running light for each pump.
- 7. Alarm Signal Device: Sounds alarm when backup pumps are operating.
 - a. Time Delay: Controls alarm operation; adjustable from 1 to 300 seconds, with automatic or manual reset.
- 8. Thermal-bleed cutoff.
- 9. Low-suction-pressure cutout.
- 10. High-suction-pressure cutout.
- 11. Low-discharge-pressure cutout.
- 12. High-discharge-pressure cutout.
- 13. Direct Digital Control (DDC) System for HVAC: Provide auxiliary contacts for interface to BACnet DDC system. DDC systems are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC." Include the following:
 - a. On-off status of each pump.
 - b. Alarm status.
- J. Base: Structural steel.
- 2.3 CONTROLS
 - A. Aquastat: Electric; adjustable for control of hot-water circulation pump.
 - 1. Type: Water-immersion temperature sensor, for installation in piping.
 - 2. Range: 65 to 200 deg F .
 - 3. Operation of Pump: On or off.
 - 4. Transformer: Provide if required.
- 2.4 MOTORS
 - A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors.
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in NFPA 70.
- 2.5 SOURCE QUALITY CONTROL
 - A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

- B. ASME Compliance: Comply with ASME B31.9 for piping.
- C. UL Compliance for Packaged Pumping Systems:
 - 1. UL 508, "Industrial Control Equipment."
 - 2. UL 508A, "Industrial Control Panels."
 - 3. UL 778, "Motor-Operated Water Pumps."
 - 4. UL 1995, "Heating and Cooling Equipment."
- D. Booster pumps shall be listed and labeled as packaged pumping systems by testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for domestic-water-piping system to verify actual locations of piping connections before pump installation.

3.2 INSTALLATION

- A. Comply with HI 1.4.
- B. Mount pumps in orientation complying with manufacturer's written instructions.
- C. Install continuous-thread hanger rods and vibration isolation of size required to support pump weight.
- D. Install thermostats in hot-water return piping.
- E. Install time-delay relays in piping between water heaters and hot-water storage tanks.
- F. Booster-Pump Mounting:
 - 1. Install booster pumps on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 220500 "Common Work Results for Plumbing."
- G. Support connected domestic-water piping so weight of piping is not supported by booster pumps.

3.3 PIPING CONNECTIONS

- A. Where installing piping adjacent to domestic water pumps, allow space for service and maintenance.
- B. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
- C. Install flexible connectors adjacent to pumps in suction and discharge piping of pumps. Comply with requirements for flexible connectors specified in Section 220500 "Basic Piping Materials and Methods Requirements"
- D. Inline Pump Piping Connections: Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping.
 - 1. Install pressure gauge and snubber at suction of each pump and pressure gauge and snubber at discharge of each pump. Install at integral pressure-gauge tapings where provided or install pressure-gauge connectors in suction and discharge piping around pumps.

- E. **Booster-Pump Piping Connections:** Connect domestic-water piping to booster pumps. Install suction and discharge pipe equal to or greater than size of system suction and discharge headers.
 - 1. Install shutoff valves on piping connections to booster-pump suction and discharge headers. Install ball, butterfly, or gate valves same size as suction and discharge headers.
 - 2. Install union, flanged, or grooved-joint connections on suction and discharge headers at connection to domestic-water piping.
 - 3. Install valved bypass, same size as and between piping, at connections to booster-pump suction and discharge headers.
 - 4. Install flexible connectors, same size as piping, on piping connections to booster-pump suction and discharge headers.

3.4 ELECTRICAL CONNECTIONS

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

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between temperature controllers and devices.
- C. Interlock pump between water heater and hot-water storage tank with water heater burner and time-delay relay.

3.6 IDENTIFICATION

- A. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs.
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Perform visual and mechanical inspection.
 - 2. Leak Test: After installation, charge booster pump and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start booster pumps to confirm proper motor rotation and booster-pump operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Pumps and controls will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 STARTUP SERVICE

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

3.9 ADJUSTING

- A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust pressure set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges per manufacturer's recommendations
- D. Booster Pump Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting booster pump to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

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

END OF SECTION 221123

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. Hub-and-spigot, cast-iron soil pipe and fittings.
 - 2. Hubless, cast-iron soil pipe and fittings.
 - 3. Copper tube and fittings.
 - 4. PVC pipe and fittings.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
- B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.
 - 2. Waste, Pressure Piping: 100 psig .

2.2 PIPING MATERIALS

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- C. Hub-and-spigot, cast-iron soil pipe and fittings: pipe and fittings meeting ASTM A74, service and extra heavy classes. ASTM C 564, rubber gaskets.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AB & I Foundry; a part of the McWane family of companies.
 - b. Charlotte Pipe and Foundry Company.
 - c. Tyler Pipe / Soil Pipe Division
- D. Hubless, cast-iron soil pipe and fittings: pipe and fittings meeting ASTM A 888 or CISPI 301. Couplings and compression gaskets meeting ASTM C564 and CISPI 310. Heavy-duty hubless couplings and compression gaskets meeting ASTM C1540
 - 1. Piping Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AB & I Foundry; a part of the McWane family of companies.

- b. Charlotte Pipe and Foundry Company.
 - c. Tyler Pipe; a part of McWane family of companies.
- 2. Hubless Coupling Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Ideal Tridon Group.
 - c. Mission Rubber Company, LLC; a division of MCP Industries.
 - d. Tyler Pipe; a subsidiary of McWane Inc.

2.3 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- C. 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.
- D. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.4 PVC PIPE AND FITTINGS

- A. Comply with NSF 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.
- B. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
- C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- D. Adhesive Primer: ASTM F 656.
- E. Solvent Cement: ASTM D 2564.

PART 3 - EXECUTION

3.1 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil, waste, and vent piping shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings; CISPI hubless-piping couplings; and coupled joints on piping 3" and smaller.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints on piping 4" and larger.
 - 3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
- C. Underground, soil, waste, and vent piping shall be:
 - 1. Service class, hub-and-spigot, cast-iron soil piping; gaskets; and gasketed joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

- D. Aboveground pressure piping shall be any of the following:
 1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 2. Schedule 80 PVC pressure pipe; schedule 80 fittings; and solvent cement socket joints.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 2. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Install piping to allow application of insulation.
- I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of waste piping in direction of flow is prohibited.
- J. Lay buried building waste piping beginning at low point of each system.
 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 3. Maintain swab in piping and pull past each joint as completed.
- K. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
 1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.
 2. Sanitary Vent: 0.5 percent down toward vertical fixture vent or toward vent stack.

- L. 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."
- M. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- N. Install aboveground PVC piping according to ASTM D 2665.
- O. Install underground PVC piping according to ASTM D 2321.
- P. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary waste gravity-flow piping.
 - a. Comply with requirements for cleanouts specified in Section 221319 "Sanitary Waste Piping Specialties."
- Q. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors. Install sleeve seals for piping penetrations of concrete walls and slabs. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 - 1. Comply with requirements for sleeves and escutcheons specified in Section 220500 "Basic Piping Materials and Methods Requirements."

3.3 JOINT CONSTRUCTION

- A. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- B. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.
 - 1. Cut threads full and clean using sharp dies.
 - 2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 - c. Do not use pipe sections that have cracked or open welds.
- D. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- E. Plastic, Nonpressure-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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Comply with requirements for installation of transition couplings and dielectric fittings specified in 220500 “Basic Piping Materials and Methods Requirements.”

3.5 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect waste and vent piping to the following:
 - 1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Equipment: Connect waste piping as indicated.
 - a. Provide shutoff valve if indicated and union for each connection.
 - b. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- E. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.

3.6 FIELD QUALITY CONTROL

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

unconcealed new, altered, extended, or replaced waste and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
3. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
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.

3.7 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping, drains, and drain openings 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 PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.
- E. Repair damage to adjacent materials caused by waste and vent piping installation.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cleanouts.
 - 2. Miscellaneous sanitary drainage piping specialties.
 - 3. Floor drains.
 - 4. Floor sinks.
 - 5. Trench drains.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Operation and Maintenance Data: For backwater valves to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

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

2.2 CLEANOUTS

- A. Cleanout plugs, floor cleanouts, wall cleanouts : Meeting ASME A112.36.2M
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg Co; a division of Morris Group International.
 - 2. Josam Company.
 - 3. MIFAB, Inc.
 - 4. Tyler Pipe; a subsidiary of McWane Inc.
 - 5. WATTS.
 - 6. Zurn Industries, LLC.

2.3 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.

2.4 FLOOR DRAINS

- A. Floor Drains: Meeting ASME A112.6.3
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg Co; a division of Morris Group International.

2. Josam Company.
3. MIFAB, Inc.
4. Tyler Pipe; a subsidiary of McWane Inc.
5. WATTS.
6. Zurn Industries, LLC.

2.5 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

- A. Hub drains: Shop or field fabricate from ASTM A74, Service Class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C564 rubber gaskets. Size shall be same as connected waste piping with increaser fitting if indicated on drawings.
- B. Trap Seal Device: Meeting ASSE 1072
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam.
 - c. Provent Systems.
- C. No-hub fitting restraints: Pre-engineered kits of galvanized steel pipe straps with d steel band clamps and tee bolts, meeting requirements of the CISPI Installation Handbook.
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Holdrite.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Assemble hub drain fittings and install with top of hub 1 inch above floor.
- E. Trap primer: Install 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.

- F. Trap seal: Install trap seals in accordance with manufacturer's written instructions and in locations indicated. Make watertight seal using an adhesive type caulk along bottom of trap seal, if required by the manufacturer. Employ a test plug for testing and remove before normal floor drain use. Clean inside of drain tailpiece and install trap seal after testing. Do not touch elastomeric plug or allow contact with primer or solvent cement.
- G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- H. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
- I. Install No-Hub fitting restraints on joints 5" and larger at:
 - 1. Changes of direction from vertical to horizontal
 - 2. 4" branch connections, including tees, wyes and wye combination fittings to soil and waste piping 5" and larger
 - 3. Horizontal changes of direction 22-1/2 degrees and greater
- J. Install wood-blocking reinforcement for wall-mounting-type specialties.
- K. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- L. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 - 2. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

3.2 PROTECTION

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

END OF SECTION 221319

SECTION 221363 - FACILITY GRAY-WATER STORAGE TANKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Steel, pressure, water storage tank.
 - 2. Plastic, nonpressure, water storage tanks.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for gray-water storage tanks.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Qualification Data: For manufacturer.
- D. Welding certificates.
- E. Maintenance Data: For gray-water storage tanks to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Fabricator Qualifications: Employ a qualified structural engineer to prepare calculations, Shop Drawings, and other structural data for fabrication and erection of surface water-storage tanks.
 - 1. Engineering Responsibility: Preparation of data for surface water-storage tanks, accessories, specified appurtenances, and concrete supports and foundations, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
 - 2. AWS D1.3/D1.3M, "Structural Welding Code - Sheet Steel."
 - 3. AWS D1.4/D1.4M, "Structural Welding Code - Reinforced Steel."
- C. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with AWWA D100, "Welded Steel Tanks for Water Storage," and with AWWA M42, "Steel Water-Storage Tanks."
- B. Comply with AWWA D120, "Thermosetting Fiberglass-Reinforced Plastic Tanks."

2.2 STEEL, PRESSURE, WATER STORAGE TANKS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Flexcon.
 - 2. Wessels Company.
- B. Description: Steel, pressure-rated tank with cylindrical sidewalls.
- C. Fabricate supports and attachments to tank with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure.
- D. Construction: Steel, constructed with nontoxic welded joints, for 150-psig working pressure.
- E. Tappings: Factory-fabricated[**stainless**] steel, welded to tank[**before testing and labeling**].
 - 1. NPS 2 and Smaller: ASME B1.20.1, with female thread.
 - 2. NPS 2-1/2 and Larger: ASME B16.5, flanged.
- F. Specialties and Accessories: Include tappings in tank and the following:
 - 1. Pressure relief valve.
 - 2. Pressure gage.
 - 3. Thermometer.
 - 4. Air-charging connection.
 - 5. Gage glass, brass fittings, compression stops, and gage-glass guard.
- G. Horizontal Tank Supports: Factory-fabricated steel saddles, welded to tank.
- H. Exterior Coating: Manufacturer's standard enamel paint.

2.3 PLASTIC, NONPRESSURE, WATER STORAGE TANKS

- A. FRP Water Storage Tanks:
 - 1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
 - 2. Description: FRP, vertical, nonpressure-rated water tank.
 - 3. Construction: [ASTM D3299, filament-wound] [or] [ASTM D4097, contact-molded] FRP.
 - 4. Tappings: Factory-fabricated, FRP flanged-end nozzle.
 - a. NPS 2 and Smaller: Include plastic-to-steel transition fitting from tank nozzle flange to ASME B1.20.1, female thread.
 - 1) **[Exception: Tappings may be threaded FRP coupling integral with nozzle for connections for plastic piping.]**
 - b. NPS 2-1/2 and Larger: Flanged.
 - 5. Vertical Tank Support: Separate factory-fabricated steel stand capable of supporting tank.
- B. Manhole: Watertight, for tank more than [36 inches] <Insert dimension> in diameter.
- C. Cover for Open Tank: Plastic, same as or similar to tank material and with shape that encloses top of tank.

D. Specialties and Accessories: Includeappings in tank and the following:

1. Vacuum relief valve.
2. Free air vent with insect screen.
3. Thermometer.
4. Gage glass, brass fittings, compression stops, and gage-glass guard.

2.4 PAINT MATERIALS

- A. Paint: Comply with AWWA D102.
- B. Primer: Tank fabricator's standard epoxy-polyamide paint.
- C. Tank Shell Exterior Intermediate Paint: Tank fabricator's standard, two-component epoxy paint compatible with prime and finish paint. Intermediate coat shall have a slight color contrast with finish coat.
- D. Tank Shell Exterior Finish Paint: Tank fabricator's standard urethane paint.
 1. Color: [**As selected by Owner from tank manufacturer's paint chart**] <Insert color>.

2.5 SHOP PAINTING

- A. Tank Shell Exterior Finish Coat: Factory coating according to AWWA D103.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.
 1. Install horizontal tanks on [**concrete piers and factory-fabricated**] [**fabricated steel supports and**] saddles.
- B. Vertical Water Storage Tanks:
 1. Install on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- C. Anchor tank supports and tanks to substrate.
 1. Use steel or FRP straps over or around plastic tanks.
- D. Install tank seismic restraints.
- E. Install thermometers and pressure gages on water storage tanks and piping if indicated. Thermometers and pressure gages are specified in Section 220519 "Meters and Gages for Plumbing Piping."
- F. Install the following devices on tanks:
 1. Pressure relief valves.
 2. Temperature and pressure relief valves.
 3. Vacuum relief valves.
 4. Tank vents on nonpressure tanks.
 5. Connections to accessories.
- G. After installing tanks with factory finish, inspect finishes and repair damages to finishes.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections[**with the assistance of a factory-authorized service representative**]:

1. Tank Weld Test: Use radiographic method according to AWWA D100. Repair failures and retest.
 2. Leak Test: Comply with AWWA D100[**and NFPA 22**]. Fill tanks with water and test for leaks after installation. Repair leaks and retest until no leaks exist.
 - a. Water will be furnished by Owner.
 3. Leak Test: Comply with [**AWWA D110**] [**AWWA D115**] [**and NFPA 22**]. Fill tanks with water and test for leaks after installation. Repair leaks and retest until no leaks exist.
 - a. Water will be furnished by Owner.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Water storage tanks will be considered defective if they do not pass test and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 221363

SECTION 221413 - STORM AND CONDENSATE DRAIN PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hub-and-spigot, cast-iron soil pipe and fittings.
 - 2. Hubless, cast-iron soil pipe and fittings.
 - 3. Copper tube and fittings.
 - 4. PVC pipe and fittings.
 - 5. Specialty pipe and fittings.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Field quality-control reports.

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 - 1. Storm Drainage Piping: 10-foot head of water.
 - 2. Storm Drainage, Pressure Piping: 100 psig.
 - 3. Condensate-Drain Piping: 150 deg F.

2.2 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AB & I Foundry; a part of the McWane family of companies.
 - 2. Charlotte Pipe and Foundry Company.
 - 3. Tyler Pipe / Soil Pipe Division
- B. Pipe and Fittings:
 - 1. Marked with CISPI collective trademark and NSF certification mark.
 - 2. Class: ASTM A 74, Service class(es).
- C. Gaskets: ASTM C 564, rubber.
- D. Caulking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Hubless, cast-iron soil pipe and fittings: pipe and fittings meeting ASTM A 888 or CISPI 301. Couplings and compression gaskets meeting ASTM C564 and CISPI 310. Heavy-duty hubless couplings and compression gaskets meeting ASTM C1540

1. Piping Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AB & I Foundry; a part of the McWane family of companies.
 - b. Charlotte Pipe and Foundry Company.
 - c. Tyler Pipe; a part of McWane family of companies.
2. Hubless Coupling Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Ideal Tridon Group.
 - c. Mission Rubber Company, LLC; a division of MCP Industries.
 - d. Tyler Pipe; a subsidiary of McWane Inc.

2.4 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type M, water tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast-copper fittings or ASME B16.29, wrought-copper, solder-joint fittings.
- C. Hard Copper Tube: ASTM B 88, Type L, water tube, drawn temper.
- D. Copper Pressure Fittings:
 1. Copper Fittings: ASME B16.18, cast-copper-alloy fittings 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.
- E. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.5 PVC PIPE AND FITTINGS

- A. NSF Marking: Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic storm drain and "NSF-sewer" for plastic storm sewer piping.
- B. Solid-Wall PVC Pipe: ASTM D 2665; drain, waste, and vent.
- C. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.
- D. Adhesive Primer: ASTM F 656.
- E. Solvent Cement: ASTM D 2564.

2.6 SPECIALTY PIPE FITTINGS

- A. Transition Couplings: Fitting or device for joining piping with small differences in ODs or of different materials. Include end connections same size as and compatible with pipes to be joined. Comply with requirements for transition fittings specified in 220500 "Basic Piping Materials and Methods Requirements."
- B. Dielectric Fittings: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined. Comply with

requirements for dielectric fittings specified in 220500 “Basic Piping Materials and Methods Requirements.”

PART 3 - EXECUTION

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 the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty, hubless-piping couplings; and coupled joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- C. Underground storm drainage piping shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
 - 3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- D. Condensate piping shall be any of the following:
 - 1. Hard Copper Tube, ASTM B 88, Type M, water tube, drawn temper.
 - 2. Hard Copper Tube, ASTM B 88, Type L, water tube, drawn temper.
 - 3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 - 2. Install piping as indicated unless deviations 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 to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for piping using appropriate branches, bends, and long-sweep bends.
 - 1. Do not change direction of flow more than 90 degrees.

2. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of drainage piping in direction of flow is prohibited.
 - K. Lay buried building piping beginning at low point of each system.
 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 3. Maintain swab in piping and pull past each joint as completed.
 - L. Install piping at a minimum slope of 1% downward in direction of flow unless otherwise indicated.
 - M. 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."
 - N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
 - O. Install aboveground PVC piping according to ASTM D 2665.
 - P. Install underground PVC piping according to ASTM D 2321.
 - Q. Install underground, copper, pressure pipe according to CDA's "Copper Tube Handbook."
 - R. 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.
 2. Install drains in storm drainage gravity-flow piping.
 - S. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 - T. Install sleeves for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for sleeves specified in Section 220500 "Basic Plumbing Materials and Methods Requirements."
 - U. Install sleeve seals for piping penetrations of concrete walls and slabs.
 1. Comply with requirements for sleeve seals specified in Section 220500 "Basic Plumbing Materials and Methods Requirements."
 - V. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for escutcheons specified in Section 220500 "Basic Plumbing Materials and Methods Requirements."
- 3.3 JOINT CONSTRUCTION
- A. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
 - B. Hubless, Cast-Iron Soil Piping Coupled Joints:
 1. Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.

- C. Join copper tube and fittings with soldered joints according to ASTM B 828 procedure. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.
- D. 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. PVC Piping: Join according to ASTM D 2855 and ASTM D 2665 appendices.
- E. No-hub fitting restraints and sway bracing:
 - 1. Provide no-hub fitting restraints and sway bracing for storm drainage piping joints to comply with the following conditions:
 - a. Provide no-hub fitting restraint for pipe and fittings 5 inches and larger, upstream and downstream of all changes in direction, branches, and changes in diameter greater than two pipe sizes.
 - b. Provide rigid sway bracing for all horizontal piping at not more than 40' intervals to prevent horizontal movement.

3.4 SPECIALTY PIPE FITTING INSTALLATION

- A. Comply with requirements for installation of transition couplings and dielectric fittings specified in 220500 "Basic Piping Materials and Methods Requirements."

3.5 VALVE INSTALLATION

- A. Shutoff Valves:
 - 1. Install shutoff valve on each sump pump discharge.
 - 2. Install gate valve for piping NPS 2-1/2 and larger.
- B. Check Valves: Install swing-check valve, between pump and shutoff valve, on each sump pump discharge.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect storm drainage piping to roof drains and storm drainage specialties.
 - 1. Install test tees (wall cleanouts) in conductors near floor, and floor cleanouts with cover flush with floor.
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.
- E. Make connections according to the following unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 - 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.7 IDENTIFICATION

- A. Identify exposed storm drainage piping.

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. 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.
 - a. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure:
 - a. Test storm drainage piping, except outside leaders, on completion of roughing-in.
 - b. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. 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.
- C. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 - 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.
 - a. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 4. Prepare reports for tests and required corrective action.
- D. Piping will be considered defective if it does not pass tests and inspections.

- E. Prepare test and inspection reports.

3.9 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.

END OF SECTION 221413

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Metal roof drains.
 - 2. Miscellaneous storm drainage piping specialties.
 - 3. Cleanouts.

1.2 SUBMITTALS

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

1.3 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

- A. Cast-Iron, General-Purpose Roof Drains:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Sioux Chief Manufacturing Company, Inc.
 - e. Watts Water Technologies; a Watts company.
 - f. Zurn Industries, LLC.
 - 2. Standard: ASME A112.6.4.

2.2 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

- A. Downspout Nozzles:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. Watts Water Technologies; a Watts company.
 - d. Zurn Industries, LLC.
 - 2. Description: Nozzle with wall flange and mounting holes to cover rough opening and serve as anchor.

2.3 CLEANOUTS

- A. Cast-Iron Exposed Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Watts Water Technologies; a Watts company.
 - e. Zurn Industries, LLC.
 2. Standard: ASME A112.36.2M.
 3. Size: Same as connected branch.
 4. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
 5. Closure: Raised head plug matching pipe material.
 6. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.
- B. Cleanout plugs, floor cleanouts, wall cleanouts : Meeting ASME A112.36.2M
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. WATTS.
 - e. Zurn Industries, LLC.
- C. Test Tees:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts Water Technologies; a Watts company.
 - f. Zurn Industries, LLC.
 2. Standard: ASME A112.36.2M and ASTM A74, ASTM A888, or CISPI 301.
 3. Size: Same as connected drainage piping.
 4. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
 5. Closure Plug: raised head, matching pipe material.
 6. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas in accordance with 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 nozzles at exposed bottom of conductors where they spill onto grade.
- C. Install cleanouts in aboveground piping and building drain piping in accordance with the following instructions unless otherwise indicated:
 - 1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 - 3. Locate cleanouts at maximum intervals of 100 feet of developed length.
 - 4. Locate cleanouts at base of each vertical storm piping conductor.
- D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- F. Install test tees in vertical conductors and near floor.
- G. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.
- H. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- I. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.

3.2 INSTALLATION OF FLASHING

- A. Fabricate flashing from single piece of metal unless large pans, sumps, or other drainage shapes are required.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

3.3 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. Exposed PVC piping: Protect storm drainage piping exposed to sunlight with 2 coats of a water based latex paint.

- C. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 221423

SECTION 221429 - SUMP AND CONDENSATE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sump pumps.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. 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.
4. Include diagrams for power, signal, and control wiring.

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

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

2.2 SUBMERSIBLE SUMP PUMPS

A. Submersible, Fixed-Position, Single-Seal Sump Pumps:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett; a Xylem brand.
 - b. Goulds Water Technology; a Xylem brand.
 - c. Grundfos Pumps Corporation.
 - d. Weil Pump; a Wilo 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 as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Impeller: Statically and dynamically balanced, ASTM A48/A48M, Class No. 25 A cast iron design for clear wastewater handling, and keyed and secured to shaft.
6. Pump and Motor Shaft: Stainless steel with factory-sealed, grease-lubricated ball bearings.
7. 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.
 - a. Motor Housing Fluid: Air.
9. Controls:
 - a. Enclosure: NEMA 250, Type 4X; wall mounted.
 - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. Automatic Alternator: Start pumps on successive cycles and start multiple pumps if one cannot handle load.
 - d. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
10. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.

2.3 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."
 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.

3.3 CONNECTIONS

- A. Install a non clog check valve in an accessible location or where indicated on the drawings. Install a full port ball valve on the discharge side of sump pumps downstream of the check valve.
- B. Install inlets or outlets to fiberglass sump basins in the field at the required elevation. Cut inlet or outlet per the basin manufacturers instructions, as installation requires with factory penetration kits at each penetration. See drawings for inlet and outlet elevations.
- C. Install sump basin inlets or outlets in the field at the required elevation. Seal penetrations with mechanical link seals. Mechanical link seals are specified in Division 22 Section "Basic Piping Material and Methods."
- D. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.
- B. Pumps and controls will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.

3.6 DEMONSTRATION

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

END OF SECTION 221429

SECTION 223200 - DOMESTIC WATER FILTRATION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Bag-type filters.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For water filtration equipment. 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.
- C. Certificates of Shop Inspections and Data Reports: For products required to have ASME label, signed by product manufacturer.
- D. Welding certificates.
- E. Source quality-control reports.
- F. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For water filtration equipment to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of water filtration equipment through one source from a single manufacturer.
- B. Welding Qualifications: Qualify processes 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. Comply with NSF 61 Annex, "Drinking Water System Components - Health Effects," for all components that will be in contact with potable water.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with actual equipment provided.

PART 2 - PRODUCTS

2.1 BAG-TYPE FILTERS

- A. Description: Simplex, floor-mounted housing with single-bag filter for removing suspended particles from water.

1. Housing: Corrosion resistant; designed to separate feedwater from filtrate and to direct feedwater through bag-type water filter(s); with bag support and base, feet, or skirt.
 - a. Material: [**Carbon steel with NSF 61 Annex lining material**] [**Plastic**] [**Stainless steel**].
 - b. Seals: [**NBR**] **<Insert material>**.
 - c. Bag Support: Top lock ring and perforated [**stainless-steel**] **<Insert material>** basket.
 - d. Pipe Connections NPS 2 and Smaller: Threaded according to ASME B1.20.1.
 - e. Steel Housing Pipe Connections NPS 2-1/2 and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if housing is stainless steel.
 - f. Plastic Housing Pipe Connections NPS 2-1/2 and Larger: 150-psig plastic flanges.
 2. Bag: Replaceable; of shape to fit housing.
- B. Capacity and Characteristics:
1. Filtrate Design Concentrations:
 - a. Alkalinity: **<Insert ppm>**.
 - b. Chlorine: **<Insert ppm>**.
 - c. Color: **<Insert nephelometric turbidity units>**.
 - d. Hydrogen Sulfide: **<Insert ppm>**.
 - e. Iron: **<Insert ppm>**.
 - f. Manganese: **<Insert ppm>**.
 - g. Sand: **<Insert ppm>**.
 - h. Silt: **<Insert ppm>**.
 - i. Turbidity: **<Insert ppm>**.
 - j. **<Insert characteristic>**: **<Insert value>**.
 2. Filter Design:
 - a. Continuous Flow: **<Insert gpm>**.
 - b. Peak Flow: **<Insert gpm>**.
 - c. Filtration Efficiency: [**98**] **<Insert number>** percent retention of suspended particles [**10**] [**20**] **<Insert size>** micrometers and larger from feedwater of listed filtrate design concentrations.
 - d. Pressure Drop: Not to exceed [**2 psig**] **<Insert value>** at filter design flow rate when clean[**and <Insert value> when dirty**].
 3. Housing:
 - a. Pressure Rating: **<Insert psig>**.
 - b. Diameter: **<Insert inches>**.
 - c. Height or Length: **<Insert inches>**.

- d. Inlet and Outlet Size: <Insert NPS>.
- e. Drain Size: [Not applicable] <Insert NPS>.
- 4. Bag:
 - a. Nominal Diameter: <Insert inches>.
 - b. Nominal Length: <Insert inches>.
 - c. Media: [Cotton] [Polyester] [PP] <Insert material>; [felt, filament, or mesh] [felt] [filament] [mesh] construction.

2.2 SOURCE QUALITY CONTROL

- A. Before shipping, hydrostatically test [carbon filters,] [circulating sand filters,] [multimedia sand filters,] [greensand filters,] [and] [separators] to minimum of one and one-half times pressure rating.
- B. Prepare test reports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of [filters] [and] [separators].
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls and floors for suitable conditions where [filters] [and] [separators] will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT MOUNTING

- A. Equipment Mounting: Install [filters, except wall-mounted cartridge filters,] [and] [separators] on concrete bases. Comply with requirements for concrete bases specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.3 BAG-TYPE FILTER INSTALLATION

- A. Equipment Mounting: Install filters on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
- B. Install bag-type filters 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.

- C. Install filter media bags.
- D. Install seismic restraints for bag-type filter housings and anchor to building structure.

3.4 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 equipment to allow service and maintenance.
- C. Make piping connections between water filtration equipment and dissimilar-metal water piping with dielectric fittings. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- D. Install shutoff valves on feedwater-inlet and filtrate-outlet piping of each water filtration equipment **[filter]** **[and]** **[separator]** **[and on inlet and outlet headers]**.
 - 1. Comply with requirements for metal general-duty valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
 - 2. Comply with requirements for plastic valves specified in Section 221116 "Domestic Water Piping."
 - 3. Exception: Water filtration equipment with factory-installed shutoff valves at locations indicated.
- E. Install pressure gages on feedwater-inlet and filtrate-outlet piping of each water filtration equipment **[filter]** **[and]** **[separator]**. Comply with requirements for pressure gages specified in Section 220519 "Meters and Gages for Plumbing Piping."
 - 1. Exception: Water filtration equipment with factory-installed pressure gages at locations indicated.
 - 2. Exception: Cartridge water filters.
- F. Install valved bypass water piping around each water filtration equipment **[filter]** **[and]** **[separator]**.
 - 1. Comply with requirements for metal general-duty valves specified in Section 220523.12 "Ball Valves for Plumbing Piping," Section 220523.13 "Butterfly Valves for Plumbing Piping," Section 220523.14 "Check Valves for Plumbing Piping," and Section 220523.15 "Gate Valves for Plumbing Piping."
 - 2. Comply with requirements for plastic valves specified in Section 221116 "Domestic Water Piping."
 - 3. Comply with requirements for water piping specified in Section 221116 "Domestic Water Piping."
 - 4. Exception: Bag-type water filtration equipment.
 - 5. Exception: Cartridge water filtration equipment.
- G. Install drains as indirect wastes to spill into open drains or over floor drains.

3.5 IDENTIFICATION

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

3.6 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Domestic water filtration equipment will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. **[Engage a factory-authorized service representative to perform] [Perform]** startup service for **[circulating sand filters,] [multimedia sand filters,] [greensand filters,] [and] [separators].**
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. **<Insert startup steps if any>.**
- B. Sample **[filter] [and] [separator]** filtrate after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics.

3.8 DEMONSTRATION

- A. **[Engage a factory-authorized service representative to train] [Train]** Owner's maintenance personnel to adjust, operate, and maintain **[circulating sand filters,] [multimedia sand filters,] [greensand filters,] [and] [separators].**

END OF SECTION 223200

SECTION 223300 - ELECTRIC, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 1. Commercial, electric, storage, domestic-water heaters.
 2. Domestic-water heater accessories.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Operation and Maintenance Data: For electric, domestic-water heaters to include warranty, and emergency, operation, and maintenance manuals.

1.4 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.5 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of electric, domestic-water heaters that fail in materials or workmanship within specified warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.
- B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- C. ASME Compliance: Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61 and NSF 372.
- E. Storage tank water heaters shall comply with standard UL 1453.

2.2 COMMERCIAL, ELECTRIC, STORAGE, DOMESTIC-WATER HEATERS:

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. A. O. Smith Corporation.
 2. Lochinvar, LLC.
 3. PVI; A WATTS Brand.

4. Rheem Manufacturing Company.
 5. State Industries.
 - B. Standard: UL 1453.
 - C. Storage-Tank Construction:
 1. Tappings: Factory fabricated of materials compatible with tank and piping connections. Attach tappings to tank before testing.
 - a. NPS 2 and Smaller: Threaded ends in accordance with ASME B1.20.1.
 - b. NPS 2-1/2 and Larger: Flanged ends in accordance with ASME B16.5 for steel and stainless steel flanges, and in accordance with ASME B16.24 for copper and copper-alloy flanges.
 2. Pressure Rating: 150 psig.
 3. Interior Finish: Comply with NSF 61 and NSF 372 barrier materials for potable-water tank linings, including extending lining material into tappings.
 - D. Factory-Installed, Storage-Tank Appurtenances:
 1. Anode Rod: Replaceable magnesium.
 2. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 3. Drain Valve: Corrosion-resistant metal with hose-end connection.
 4. Insulation: Comply with ASHRAE/IES 90.1.
 5. Jacket: Steel with enameled finish or high-impact composite material.
 6. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.
 7. Heat-Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
 8. Temperature Control: Adjustable thermostat.
 9. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
 10. 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 working-pressure rating of domestic-water heater. Select one relief valve with sensing element that extends into storage tank.
 - E. Special Requirements: NSF 5 construction.
- 2.3 DOMESTIC-WATER HEATER ACCESSORIES
- A. Domestic-Water Expansion Tanks:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. A. O. Smith Corporation.
 - b. AMTROL, Inc.
 - c. State Industries.
 2. Source Limitations: Obtain domestic-water expansion tanks from single source from single manufacturer.

3. 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.
 4. 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 and NSF 372 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
 - B. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than 2" greater than heater diameter, and include drain outlet not less than NPS 3/4 with ASME B1.20.1 pipe threads.
 - C. Piping-Type Heat Traps: Field-fabricated piping arrangement in accordance with ASHRAE/IES 90.1.
 - D. Heat-Trap Fittings: ASHRAE/IES 90.1.
 - E. Manifold Kits: Domestic-water-heater manufacturer's factory-fabricated inlet and outlet piping for field installation, for multiple domestic-water heater installation. Include ball-, butterfly-, or gate-type shutoff valves to isolate each domestic-water heater and calibrated balancing valves to provide balanced flow through each domestic-water heater.
 - F. 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 working-pressure rating of domestic-water heater. Select relief valves with sensing element that extends into storage tank.
 - G. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than working-pressure rating of domestic-water heater.
 - H. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
 - I. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Include dimension that will support bottom of domestic-water heater.
 - J. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.
- 2.4 SOURCE QUALITY CONTROL
- A. Factory Tests: Test and inspect domestic-water heaters specified to be ASME-code construction, in accordance with ASME Boiler and Pressure Vessel Code.
 - B. Hydrostatically test domestic-water heaters to minimum of one and one-half times pressure rating before shipment.
 - C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
 - D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Electric, Domestic-Water Heater Mounting: Install commercial, electric, domestic-water heaters on concrete base.
 - 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. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 6. Anchor domestic-water heaters to substrate.
- B. Install electric, domestic-water heaters level and plumb, in accordance with 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.
- C. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend domestic-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.
- D. Install thermometers on outlet piping of electric, domestic-water heaters.
- E. Assemble and install inlet and outlet piping manifold kits for multiple electric, domestic-water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each electric, domestic-water heater. Include shutoff valve and thermometer in each domestic-water heater inlet and outlet.
- F. Install piping-type heat traps on inlet and outlet piping of electric, domestic-water heater storage tanks without integral or fitting-type heat traps.
- G. Charge domestic-water expansion tanks with air to required system pressure.
- H. Install dielectric fittings in all locations where piping of dissimilar metals is to be joined. The wetted surface of the dielectric fitting contacted by potable water shall contain less than 0.25 percent of lead by weight. Comply with requirements for dielectric fittings specified in 220500 "Basic Piping Materials and Methods Requirements."

3.2 PIPING CONNECTIONS

- A. Where installing piping adjacent to electric, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.
- 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 operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Electric, domestic-water heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.
- 3.4 DEMONSTRATION
- A. Train Owner's maintenance personnel to adjust, operate, and maintain electric, domestic-water heaters..

END OF SECTION 223300

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 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:

1. Water Closets.
2. Water Closet Flushometer Valves.
3. Toilet Seats.
4. Lavatories.
5. Lavatory Faucets.
6. Drinking Fountains, Water Coolers, and Bottle Fillers.
7. Mop and Utility Sinks.
8. Sinks.
9. Sink Faucets
10. Shower Heads and Valves.
11. Outlet Boxes.
12. Hose Bibbs and Hydrants.
13. Supply Fittings.
14. Waste Fittings.
15. Supports.
16. Supplies and drains for handicap-accessible lavatories and sinks.

1.3 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with requirements of ANSI Standard A117.1, "Buildings and Facilities -- Providing Accessibility and Usability for Physically Handicapped People," Public Law 90-480, "Architectural Barriers Act, 1968," with respect to plumbing fixtures for the physically handicapped and "Americans with Disabilities Act Accessibility Guidelines for Buildings 1991" with respect to plumbing fixtures for the physically handicapped.
- B. Comply with NSF 61 Annex G and / or NSF 372 for wetted surfaces of faucets and trim containing no more than 0.25% lead by weight for domestic water distribution for drinking or cooking.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Shower valves, wash fountain spray heads, bubblers, electric water coolers, drinking fountains, bottle filling stations, and faucets intended to convey or dispense water for human consumption are to comply with the U.S. Safe Drinking Water Act (SDWA), with requirements of the Authority Having Jurisdiction (AHJ), and with NSF 61 and NSF 372, or be certified in

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

- E. Comply with the following applicable standards and other requirements specified for miscellaneous components:

- 1. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.4 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 WATER CLOSETS AND URINALS

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

- 1. American Standard.
- 2. Kohler Co.
- 3. TOTO USA, INC.
- 4. Zurn Industries, LLC.

- B. Source Limitations: Obtain water closets from single source from single manufacturer.

- C. Water closet standards:

- 1. Comply with ASME A112.19.2/CSA B45.1 for water closets.
- 2. Comply with ICC A117.1 for ADA-compliant water closets.
- 3. Comply with ASME A112.6.1M for water-closet supports
- 4. Comply with ASTM A1045 for flexible PVC gaskets used in connection of vitreous china water closets to sanitary drainage systems.
- 5. Comply with ASME A112.4.3 for plastic fittings used in connection of vitreous china water closets to sanitary drainage systems.

2.2 WATER CLOSET AND URINAL FLUSHOMETER VALVES

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

- 1. American Standard.
- 2. Sloan Valve Company.
- 3. TOTO USA, INC.
- 4. Zurn Industries, LLC.

- B. Source Limitations: Obtain flushometer valve from single source from single manufacturer.

- C. Comply with ASME A112.19.5/CSA B45.15 for flush valves and spuds for water closets, and tanks. Comply with ASSE 1037/ASME A112.1037/CSA B125.37 for flush valves.

- D. Provide flushometers compatible with fixtures, with features and of consumption indicated as described on the drawings.

- 1. Exposed metal parts shall be polished chrome plated.

2. Flush valves installed within wall construction may be without chrome plate finish.

2.3 TOILET SEATS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. American Standard.
 2. Bemis Manufacturing Company.
 3. Church Seats; Bemis Manufacturing Company.
- B. Comply with IAMPO/ANSI Z124.5 for water-closet (toilet) seats.

2.4 LAVATORIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. American Standard
 2. Kohler Co.
 3. Sloan Valve Company.
 4. TOTO USA, INC.
 5. Zurn Industries, LLC.
- B. Standard: ASME A112.19.2/CSA B45.1.

2.5 LAVATORY FAUCETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. American Standard
 2. Chicago Faucet Co.
 3. Delta Faucet Co.; Div. of Masco Corp.
 4. Kohler Co.
 5. Moen Group; Stanadyne Corp.
 6. Sloan Valve Company.
 7. TOTO USA, INC.
 8. Zurn Industries, LLC.
- B. Manually operated lavatory faucets
 1. Standard: ASME A112.18.1/CSA B125.1.
- C. Automatically operated lavatory faucets
 1. Standards: ASME A112.18.1/CSA B125.1 and UL 1951.
 2. 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.

2.6 DRINKING FOUNTAINS, WATER COOLERS, AND BOTTLE FILLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Elkay Manufacturing Co.
 - 2. Halsey Taylor; A Household International Co.
 - 3. Haws Drinking Faucet Co.
- B. Standards
 - 1. Comply with ICC A117.1 for accessible drinking fountains and bottle filling stations.
 - 2. Comply with ASHRAE 34 for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
 - 3. Comply with UL 399.
 - 4. Comply with ASME A112.19.3/CSA B45.4.
 - 5. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 6. Comply with NSF 42 and NSF 53 for water filters for water coolers and bottle filling stations.
 - 7. Comply with ICC A117.1 for accessible water coolers and bottle filling stations.

2.7 MOP AND UTILITY SINKS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. E.L. Mustee & Sons, Inc
 - 2. Fiat Products.
 - 3. Kohler Co.
 - 4. Stern-Williams Co., Inc.
 - 5. Zurn Industries, LLC.
- B. Standards
 - 1. Plastic Mop Sinks: CSA B45.5/IAPMO Z124.
 - 2. Molded Stone Mop Sinks: ASME A112.18.2/CSA B125.2.
 - 3. Utility Sinks: ASME A112.19.3/CSA B45.4.

2.8 SINKS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Elkay Manufacturing Co.
 - 2. Just Manufacturing Co.
- B. Standards: ASME A112.19.3/CSA B45.4 and NSF 61.

2.9 SINK FAUCETS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Standard
 - 2. Chicago
 - 3. Delta
 - 4. Speakman Co.
 - 5. T & S Brass and Bronze Works, Inc.
 - 6. Zurn
- B. Manually operated sink faucets
 - 1. Standard: ASME A112.18.1/CSA B125.1. ICC A117.1 for accessible (ADA) sinks.

2.10 SHOWER HEADS AND SHOWER VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acorn Engineering Co.
 - 2. Bradley Corp.
 - 3. Lawler Manufacturing Co., Inc.
 - 4. Leonard Valve Co.
 - 5. Powers Process Controls; A Unit of Mark Controls Corp.
 - 6. Speakman Co.
 - 7. Symmons Industries, Inc.
 - 8. Willoughby
- B. Standards: ASME A112.18.1/CSA B125.1 and ASSE 1016/ASME A112.1016/CSA B125.16.

2.11 OUTLET BOXES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Guy Gray Manufacturing Co., Inc.
 - 2. Oatey Co.
 - 3. Symmons Industries, Inc.

2.12 HOSE BIBBS AND HYDRANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R Smith
 - 2. Watts Drainage
 - 3. Woodford Mfg. Co.
 - 4. Zurn Industries

- B. Hose Bibbs:
 - 1. Standard: ASME A112.18.1 for sediment faucets.
 - 2. Pressure Rating: 125 psig.
- C. Wall Hydrants:
 - 1. Standard: ASME A112.21.3M for self-draining wall hydrants.
 - 2. Pressure Rating: 125 psig.
- 2.13 SUPPLY FITTINGS
 - A. Standard: ASME A112.18.1/CSA B125.1.
 - B. 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.
 - C. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
 - D. Operation: Wheel handle.
 - E. Risers: ASME A112.18.6/CSA B125.6, braided- or corrugated-stainless steel, flexible hose riser.
- 2.14 WASTE FITTINGS
 - A. Standard: ASME A112.18.2/CSA B125.2.
 - B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.
 - C. Trap: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall two-piece, cast-brass trap and ground-joint swivel elbow with 0.032-inch-thick brass tube to wall one-piece, or cast-brass trap with swivel 0.029-inch-thick tubular brass wall bend ; and chrome-plated, brass or steel wall flange.
- 2.15 SUPPORTS
 - A. Carriers:
 - 1. Source Limitations: Obtain water-closet carrier from single source from single manufacturer.
 - 2. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. When required, include additional extension coupling, faceplate, and feet for installation in wide pipe space.
 - 3. Standard: ASME A112.6.1M.
- 2.16 GROUT
 - A. Comply with ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout. Grout shall be premixed and factory packaged.
- 2.17 PROTECTIVE SHIELDING GUARDS
 - A. Protective Shielding Pipe Covers:
 - 1. 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. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION, GENERAL

A. Plumbing Fixture Installation:

1. Install all fixtures level and plumb.
2. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings.
3. Install toilet seats on water closets and combination units if seats are indicated.
4. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
5. Install supports, affixed to building substrate, for wall-mounted lavatories and sinks.
6. Seal joints between plumbing fixtures, counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant.
7. Set floor-mounted sinks in leveling bed of cement grout.
8. Install shower flow-control fittings with specified maximum flow rates in shower arms.
9. Install outletboxes recessed in wall or surface mounted on wall. Install 1-1/2-by-3-1/2-inch fire-retardant-treated-wood blocking, wall reinforcement between studs.
10. Install nonfreeze, draining-type roof hydrants with drain connection piped to nearest floor drain or to the exterior.
11. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals.
12. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system.
13. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system.
14. Install recessed, drinking fountains and bottle filling stations secured to wood blocking in wall construction.
15. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
16. Install mounting frames, affixed to building construction, and attach recessed, electric water coolers, and bottle filling stations to mounting frames.

17. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet/compartment.
18. Install new batteries in battery-powered, electronic-sensor mechanisms.

3.3 PIPING CONNECTIONS

- A. Connect plumbing fixtures with water supplies, stops, risers, and soil, waste, and vent piping. Use size fittings required to match fixture.
- B. Where installing piping adjacent to plumbing fixtures, allow space for service and maintenance.
- C. Install protective-shielding pipe covers and enclosures on exposed supplies and waste piping of accessible wash fountains.
- D. Install ball shutoff valve on water supply to each fixture. Install valve upstream from filter for drinking fountain.

3.4 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted in accordance with NFPA 70 and NECA 1.
- B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection. Nameplate to be laminated acrylic or melamine plastic signs.

3.5 IDENTIFICATION

- A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials.

3.6 ADJUSTING

- A. Operate and adjust plumbing fixtures and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust water pressure at flushometer valves, shower valves, faucets, and flow regulators to produce proper flow and stream height.

3.7 CLEANING AND PROTECTION

- A. After completing installation, inspect and repair damaged finishes on all plumbing fixtures.
- B. Clean plumbing fixtures, trim, and fittings with manufacturers' recommended cleaning methods and materials.
- C. Install protective covering for installed plumbing fixtures and fittings.
- D. Do not allow use of plumbing fixture for temporary facilities unless approved in writing by Owner.

END OF SECTION 224000

SECTION 230500 – BASIC MECHANICAL MATERIALS AND METHODS REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sleeves.
2. Grout.
3. Silicone sealants.
4. Escutcheons.
5. Transition Couplings.
6. Dielectric Fittings.
7. Flexible Connectors.
8. Drip Pans

1.2 SUBMITTALS

- ##### A. Product Data:
- Submit for approval detailed product data such as model number, all relevant ratings, country of origin, interface details as necessary, covers and main supports. A specifications compliance sheet shall be provided for each product, indicating if the proposed product comply/does not comply with each article of the related specification section.

1.3 NOISE CRITICAL SPACES

- ##### A. Many areas of the building, referred to as "noise-critical spaces", require special attention (special acoustical provisions and restrictions). The table below designates the noise-critical spaces; noise levels due to equipment, ductwork, grilles, registers, terminal devices, diffusers, etc., shall permit attaining sound pressure levels in all 8 octave bands in occupied spaces conforming to RC levels per ASHRAE handbook as indicated.
1. A/V Spaces: 25 NC
 2. TV Production Studio: 25 NC
 3. Teleconference Rooms: 25 NC
 4. Conference Rooms: 30 NC
 5. Private Offices: 35 NC

PART 2 - PRODUCTS

2.1 SLEEVES

- ##### A. Manufacturers:
- Subject to compliance with requirements, provide products by one of the following:
1. CALPICO, Inc.
 2. Metraflex Company (The).
 3. Thunderline/Link Seal.
- ##### B. Cast-Iron Pipe Sleeves:
- Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

- C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, with plain ends and integral welded waterstop collar.
- D. Stack-sleeve fitting description: Manufactured, Dura-coated or galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.
- E. Mechanical sleeve seal description:
 - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 2. Designed to form a hydrostatic seal of 20 psig minimum.
 - 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 4. Pressure Plates: Carbon steel.
 - 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B633 of length required to secure pressure plates to sealing elements.
- F. Sleeve seal fitting description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.
 - 1. Plastic or rubber waterstop collar with center opening to match piping OD.

2.2 GROUT

- A. Description: Nonshrink, for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.
- E. VOC limit: 50 g/L.

2.3 SILICONE SEALANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. GE Construction Sealants; Momentive Performance Materials Inc.
 - 2. Permthane; ITW Polymer Sealants North America.
 - 3. Polymeric Systems, Inc.
 - 4. The Dow Chemical Company.
 - 5. Tremco Incorporated.
- B. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant, ASTM C920, Type S, Grade NS, Class 25, Use NT.
- C. Silicone, S, P, 25, T, NT: Single-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant;

ASTM C920, Type S, Grade P, Class 25, Uses T and NT. Grade P Pourable (self-leveling) formulation is for opening in floors and other horizontal surfaces that are not fire rated.

- D. Silicone Foam: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.
- E. VOC limit for all sealants: 50 g/L.

2.4 ESCUTCHEONS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. BrassCraft Manufacturing Co.; a Masco company.
 - 2. Dearborn Brass.
 - 3. Jones Stephens Corp.
 - 4. Keeney Manufacturing Company (The).
 - 5. Mid-America Fittings, Inc.
 - 6. ProFlo; a Ferguson Enterprises, Inc. brand.
- B. One-Piece, Steel Type: With polished, chrome-plated finish and setscrew fastener.
- C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- D. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed hinge; and spring-clip fasteners.
- E. Split Floor Plates: Cast brass with concealed hinge.

2.5 TRANSITION COUPLINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jay R. Smith Mfg Co; a division of Morris Group International.
 - 2. Romac Industries, Inc.
 - 3. Smith-Blair, a Xylem brand.
 - 4. Viking Johnson.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Unshielded, Nonpressure Transition Couplings:
 - 1. Standard: ASTM C 1173.
 - 2. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 3. End Connections: Same size as and compatible with pipes to be joined.
 - 4. Sleeve Materials:
 - a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.

- c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
 - D. Shielded, Nonpressure Transition Couplings:
 - 1. Standard: ASTM C 1460.
 - 2. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 3. End Connections: Same size as and compatible with pipes to be joined.
 - E. Pressure Transition Couplings:
 - 1. Standard: AWWA C219.
 - 2. Description: Metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - 3. Center-Sleeve Material: Manufacturer's standard.
 - 4. Gasket Material: Natural or synthetic rubber.
 - 5. Metal Component Finish: Corrosion-resistant coating or material.
- 2.6 DIELECTRIC FITTINGS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Jomar Valve.
 - 2. Watts Water Technologies; a Watts company.
 - 3. Wilkins.
 - 4. Zurn Industries.
 - B. Dielectric Unions:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
 - C. Dielectric Flanges:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
 - D. Dielectric-Flange Insulating Kits:
 - 1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.

- b. Pressure Rating: 150 psig.
- c. Gasket: Neoprene or phenolic.
- d. Bolt Sleeves: Phenolic or polyethylene.
- e. Washers: Phenolic with steel backing washers.

2.7 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mason Industries, Inc.
 - 2. Mercer Rubber Co.
 - 3. Metraflex Co.
 - 4. Proco Products, Inc.
- B. Flexible Connectors: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections.
 - 1. Stainless-Steel-Hose, Flexible Connectors: For 2" and smaller, corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include ANSI 150# 304 stainless-steel nipples with screwed connections, welded to hose.
 - 2. Bronze Hose, Flexible Connectors: For 2" and smaller, corrugated bronze inner tubing covered with bronze wire braid. Include ANSI 150# brass nipples with screwed connections, braised to hose.
 - 3. Stainless-Steel-Hose, Flexible Connectors: For 2-1/2" and larger, corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include ANSI 150# 304 stainless-steel nipples or flanges, welded to hose.

2.8 DRIP PANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Chatsworth Products, Inc.
 - 2. RLE Technologies
 - 3. Upsite Technologies
 - 4. W.E. Anderson, a division of Dwyer Instruments
- B. Drip pans for pipes in protected areas shall be 20 gauge galvanized steel with 2" lapped and soldered joints. Drip pan shall have a depth of 2" and a width of 6" in addition to the diameter of the associated pipe. Provide 3/4" galvanized pipe with male NPT outlet at low point of drip pan.
- C. Drip pan supports shall be 1/4" X 2" galvanized bar stock welded to the drip pan without holes.
- D. Leak Detection System: Rope style leak sensor and controller capable of connecting to a building automation system with audible and visual alarms for leak detection in all drip pans unless otherwise noted on drawings.

PART 3 - EXECUTION

3.1 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 pipe sleeves, Steel pipe sleeves, or Sleeve-seal fittings.
2. Exterior Concrete Walls below Grade and Concrete Slabs-on-Grade:
 - a. Cast-iron pipe sleeves with mechanical sleeve-seal system, Steel pipe sleeves with mechanical sleeve-seal system, or Sleeve-seal fittings.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs above Grade:
 - a. Steel pipe sleeves, PVC pipe sleeves, Stack-sleeve fittings, or Sleeve-seal fittings.
 - 1) Do not use PVC pipe sleeves when exposed to return air plenums.
4. Interior Partitions:
 - a. Steel pipe sleeves or PVC pipe sleeves.
 - 1) Do not use PVC pipe sleeves when exposed to return air plenums.

3.2 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
 1. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - a. Sleeves are not required for core-drilled holes.
- B. 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 above finished floor level.
 2. Using grout or silicone sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- C. Install sleeves for pipes passing through interior partitions.
 1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.
- D. Install stack-sleeve fittings in new slabs as slabs are constructed.
 1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing.
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.

4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Use silicone sealant to seal the space around outside of stack-sleeve fittings.
 - E. Install mechanical sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
 1. 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 mechanical 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.
 - F. Install sleeve-seal fittings in new walls and slabs as they are constructed.
 1. 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.
 2. Secure nailing flanges to concrete forms.
 3. Use grout or silicone sealant to seal the space around outside of sleeve-seal fittings.
 - G. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials.
- 3.3 ESCUTCHEON AND FLOOR PLATE INSTALLATION
- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
 - B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
 1. Escutcheons for New Piping and Existing Piping:
 - a. One-piece or split-plate cast brass with polished, chrome-plated finish.
 - C. Install floor plates for piping penetrations of equipment-room floors.
 - D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 1. New Piping and Existing Piping: One-piece or split floor plate.
- 3.4 SPECIALTY PIPE FITTING INSTALLATION
- A. Transition Couplings:
 1. Install transition couplings at joints of piping with small differences in ODs.
 2. In Waste Drainage Piping: Shielded, nonpressure transition couplings.
 3. In Aboveground Pressure Piping: Fitting-type transition couplings.
 4. In Underground Pressure Piping:
 - a. NPS 1-1/2 and Smaller: Fitting-type transition couplings.
 - b. NPS 2 and Larger: Pressure transition couplings.
 - B. Dielectric Fittings:
 1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits.
4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 FLEXIBLE CONNECTORS INSTALLATION

- A. Install flexible connectors for piping system connections on equipment side of shutoff valves for all Plumbing equipment, pumps, and where indicated on Drawings.
 1. Install stainless steel connectors for domestic water copper equipment connections 2" and smaller.
 2. Install bronze connectors for non-domestic water copper equipment connections 2" and smaller.
 3. Install flanged stainless steel connectors for flanged equipment connections 2-1/2" and larger.
- B. Install connectors according to manufacturer's recommendations.

3.6 DRIP PANS INSTALLATION

- A. Provide drip pans in locations indicated on drawings.
- B. Provide drip pans for piping directly above a two hour rated ceiling of an elevator machine room.
- C. Provide drip pans, only with written approval obtained prior to installation, installed beneath piping above electrical rooms, telecom rooms, data rooms, servers or any other protected area not clearly indicated by drawings.
- D. Provide drip pan supports every 4'-0". Provide 1/4" galvanized threaded rods through bar stock on each side of the drip pan and attached with 2 nuts per rod. Attach rods to structure with MSS SP-58 compliant components.
- E. Connect 3/4" type "L" copper indirect drain line to drip pan outlet. Route and discharge to receptor with air gap outside of the protected area.
- F. Install leak detection rope in a zig-zag pattern covering entire length and width of the drip pan. Secure rope to pan per manufacturers recommendations.
- G. Mount leak detection controller on wall adjacent to exit of the room above which the drip pan is located unless otherwise indicated on drawings indicated on drawings.
- H. Coordinate disconnect and power supply for leak detection system and 120V dedicated receptacle adjacent to controller with Division 26.
- I. Coordinate interlock of "Water Present" alarm with Building Automation System.

3.7 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Leak Test: After allowing for a full cure, test sleeves and sleeve seals for leaks. Repair leaks and retest until no leaks exist.
- B. Sleeves and sleeve seals will be considered defective if they do not pass tests and inspections.
- C. Using new materials, replace broken and damaged escutcheons and floor plates.
- D. Prepare test and inspection reports.

END OF SECTION 230500

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on alternating-current power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.
- B. Motor requirements
- C. Polyphase motors
- D. Additional requirements
- E. Single-phase motors

1.2 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

1.3 QUALITY ASSURANCE

- A. Comply with NEMA MG 1 unless otherwise indicated.

PART 2 - PRODUCTS

2.1 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 104 deg F and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.2 3-PHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Premium efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.
- F. Rotor: Random-wound, squirrel cage.

- G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.3 ADDITIONAL REQUIREMENTS FOR 3-PHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.4 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
- B. Service Factor: 1.0
- C. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- D. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- E. Motors 1/20 HP and Smaller: Shaded-pole type.
- F. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230514 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Variable Frequency Drives.
 - a. Does not apply to VFD's integral to equipment. (e.g. AHUs, Fluid Coolers)

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.

B. Operation and Maintenance Data: For variable frequency drives to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Store VFDs in dry location.
- B. Retain protective covers during storage.
- C. Protect VFDs from all dust, dirt, and debris through installation and project completion.

1.4 QUALITY ASSURANCE

- A. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- 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.
- D. UL Compliance:
 1. 508A.
 2. 61800-5-1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AAB.
 2. Danfoss.
 3. Eaton.
 4. Trane.

2.2 VARIABLE FREQUENCY DRIVES.

1. Description: arranged to achieve motor variable speed by adjusting output voltage and frequency.
2. Enclosure: Hinged full-front access door with lock and key.
 - a. Located in Mechanical rooms: NEMA 250, Type 12.
 - b. Located on HVAC equipment in exterior environment: NEMA 250, Type 4.
 - c. VFD shall be plenum rated.
3. Technology: Pulse-width-modulation (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads. VFD shall be capable of providing full motor torque at any selected frequency.
4. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
5. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
6. Output signal shall be programmed to not cause mechanical vibration issues with fan drive assembly.
7. Operating Requirements:
 - a. Ambient temperature: continuous, full speed operation from 14F to 104F.
 - b. Ambient Humidity 5 to 95% relative humidity, non-condensing.
 - c. Input AC Voltage Tolerance: 10 percent.
 - d. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
 - e. Capable of driving full motor load, without derating.
 - f. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - g. Minimum Displacement Primary-Side Power Factor: 95 percent.
 - h. Overload Capability: 1.05 times the full-load current for 7 seconds.
 - i. Starting Torque: As required by fan and motor drive assembly.
 - j. Speed Regulation: 1 percent.
 - k. Speed Range: 10:1 speed range.
 - l. To avoid equipment resonant vibrations, include critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
 - m. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
8. Controller Adjustability Capabilities: Minimum and maximum output frequency, acceleration and deceleration, and current limit.
9. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or need for replacement:
 - a. Surge suppression.

- b. Loss of input signal protection.
 - c. Critical frequency rejection.
 - d. Overtemperature.
 - e. Short circuit at controller output.
 - f. Ground fault at controller output. Variable-frequency controller shall be able to start a grounded motor.
 - g. Open circuit at controller output.
 - h. Input undervoltage as low as 70%.
 - i. Input overvoltage as high as 130%.
 - j. Loss of input phase.
 - k. Reverse phase.
 - l. AC line switching transients.
 - m. Instantaneous overload, line to line or line to ground.
 - n. Sustained overload exceeding 100 percent of controller rated current.
 - o. Starting a rotating motor.
 - p. If the temperature of the VFD's heat sink rises to a critical level, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. It shall also be possible to program the VFD so that it reduces its output current limit value if the VFD's temperature becomes too high.
10. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
11. Automatic Reset and Restart:
- a. Capable of multiple restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction.
 - b. Capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
12. Visual Indication: On face of controller; indicating the following conditions:
- a. Power on.
 - b. Run.
 - c. Overcurrent and overvoltage.
 - d. Motor speed (percentage).
 - e. Various faults with alarm status.
 - f. Input kilovolt amperes.
 - g. Power factor.
 - h. Input kilowatts and kilowatt-hours.
 - i. Three-phase input and output voltage.
 - j. Three-phase input and output current.

- k. Output frequency.
 - l. Elapsed operating time (hours).
 - m. Display shall be programmable to communicate in multiple languages including English and Spanish.
 - n. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.
13. Operator Interface: Start-stop and auto-manual selector with manual-speed-control potentiometer.
- a. VFD shall have standard USB A or USB C port for direct connection of Personal Computer (PC) to the VFD. The manufacturer shall provide no-charge PC software to allow complete setup and access of the VFD and logs of VFD operation through the USB port. It shall be possible to communicate to the VFD through this USB port without interrupting VFD communications to the building management system.
14. Hardwired Control Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4 to 20 mA) and four programmable digital inputs.
15. Remote Communication Interface: ASHRAE 135 BACnet MS/TP.
16. Line Conditioning:
- a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.
17. Bypass Controller:
- a. Bypass Controller/Variable-Frequency Controller Selector Switch: Include manual selector switch on face of enclosure for local operator control of preferred controller.
 - b. Bypass Mode: Manual operation only.
 - c. Type: Integrated NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller to operate motor if variable-frequency controller is not operational.
 - d. Arrangement: Configure power supply to bypass controller and variable-frequency controller to completely isolate power to variable-frequency controller while operating fan motor through bypass controller for safe servicing of variable-frequency controller.
 - e. Enclosure: Install bypass controller in same enclosure as variable-frequency controller.
 - f. Remote Monitoring: Include control relay for remote indication of bypass controller operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in for electrical systems to verify actual locations of electrical connections before VFD installation.
- C. Examine frames and walls for suitable conditions where VFDs will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install VFD according to manufacturer's published instructions.
- B. Install VFDs level and plumb.
- C. Install VFD away from direct sunlight. Mount on north side of RTU/AHU or provide sunshading

3.3 ELECTRICAL CONNECTIONS

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

3.4 START UP SERVICE

- A. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

3.6 DEMONSTRATIONS

- A. Train Owner's maintenance personnel to adjust, operate, and maintain VFDs.

END OF SECTION 230514

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Packed expansion joints.
 - 2. Grooved-joint expansion joints.
 - 3. Alignment guides and anchors.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For each anchor and alignment guide, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
- C. Maintenance Data: For expansion joints to include in maintenance manuals.

1.3 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe and Pressure-Vessel Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with AWS D1.1/D1.1M, ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- D. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- E. Install rubber packless expansion joints according to FSA-PSJ-703.
- F. Comply with ASTM F1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

2.2 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Advanced Thermal Systems, Inc.
 - 2. Hyspan Precision Products, Inc.
 - 3. Metraflex.
 - 4. Twin City Hose.
 - 5. Victaulic Company.

2.3 PACKLESS EXPANSION JOINTS

- A. Metal, Compensator Packless Expansion Joints:
 - 1. Minimum Pressure Rating: 175 psig unless otherwise indicated.
 - 2. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
 - 3. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
 - 4. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
 - a. End Connections for Copper Tubing: Solder joint or threaded.
 - 5. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - a. End Connections for Steel Pipe: Flanged or Threaded.
- B. Metal-Bellows Packless Expansion Joints:
 - 1. Type: Circular, corrugated bellows with external tie rods.
 - 2. Minimum Pressure Rating: 175 psig, unless otherwise indicated.
 - 3. Expansion Joints for Copper Tubing: multi-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - a. End Connections for Copper Tubing: Solder joint or threaded.
 - 4. Expansion Joints for Steel Piping: multi-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
 - a. End Connections for Steel Pipe: Flanged.
- C. Rubber Packless Expansion Joints:
 - 1. Material: Fabric-reinforced rubber complying with FSA-PSJ-703.
 - 2. Type: Single or multiple with external control rods.

3. Minimum Pressure Rating: 225 psig at 170 deg F.
4. Material: Butyl rubber.
5. End Connections: Full-faced, integral steel flanges with steel retaining rings.

2.4 GROOVED-JOINT EXPANSION JOINTS

- A. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- B. Standard: AWWA C606, for grooved joints.
- C. Nipples: Galvanized, ASTM A53/A53M, Schedule 40, Type E or S, steel pipe with grooved ends.

2.5 ALIGNMENT GUIDES AND ANCHORS

- A. Alignment Guides:
 1. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
- B. Anchor Materials:
 1. Steel Shapes and Plates: ASTM A36/A36M.
 2. Bolts and Nuts: ASME B18.10 or ASTM A183, steel hex head.
 3. Washers: ASTM F844, steel, plain, flat washers.
 4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
 5. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C881/C881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 INSTALLATION OF EXPANSION JOINTS

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install packed-type expansion joints with packing suitable for fluid service.
- C. Install grooved-joint expansion joints to grooved-end steel piping.

3.2 INSTALLATION OF PIPE LOOPS AND SWING CONNECTIONS

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.
- C. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- D. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.3 INSTALLATION OF ALIGNMENT GUIDES AND ANCHORS

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Fabricate and install steel anchors by welding steel shapes, plates, and bars.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- F. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 230516

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gages.
 - 4. Gage attachments.
 - 5. Flowmeters.

1.2 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 THERMOMETERS

- A. Standard: ASME B40.200.
- B. Case: Liquid-filled stainless steel and sealed, cast aluminum and sealed, or drawn steel and sealed.
- C. Case Form: Adjustable angle, back angle, straight.
- D. Element: Bourbon tube.
- E. Movement: Mechanical, with link to pressure element and connection to pointer.
- F. Tube: Glass with magnifying lens and blue or red organic liquid.
- G. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F.
- H. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F.
- I. Pointer: Dark-colored metal.
- J. Window: Plain glass or plastic.
- K. Ring: Metal or stainless steel.
- L. Stem: Aluminum, brass, or stainless steel and of length to suit installation.
- M. Element: Bimetal coil.
- N. Connector Type(s): Union joint, adjustable angle rigid, back and rigid, bottom, with unified-inch or ASME B1.1 screw threads.
- O. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
- P. Accuracy: Plus or minus 1 percent of scale range.

2.2 THERMOWELLS

- A. Standard: ASME B40.200.
- B. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.

- C. Material for Use with Copper Tubing: CNR or CUNI.
- D. Material for Use with Steel Piping: CRES or CSA.
- E. Type: Stepped shank unless straight or tapered shank is indicated.
- F. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
- G. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
- H. Bore: Diameter required to match thermometer bulb or stem.
- I. Insertion Length: Length required to match thermometer bulb or stem.
- J. Lagging Extension: Include on thermowells for insulated piping and tubing.
- K. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.
- L. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

- A. Metal-Case, Dial-Type Pressure Gages:
 - 1. Standard: ASME B40.100.
 - 2. Case: Liquid-filled sealed type(s); cast aluminum or drawn steel.
 - 3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 - 7. Pointer: Dark-colored metal.
 - 8. Window: Glass or plastic.
 - 9. Ring: Metal, brass, or stainless steel.
 - 10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, 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, ASME B1.20.1 pipe threads.

2.5 FLOW METERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Badger.
 - 2. Onicon.
 - 3. Victaulic Company.
- B. Ultrasonic Flowmeter

1. Description: Provide a clamp-on transit time ultrasonic flow meter complete with matched transducers, self-aligning installation hardware, triaxial transducer cables and calibration certificate. When provided with the energy option, the meter shall also be provided with a matched pair of temperature sensors and temperature thermowells. Flow or thermal energy meter shall be configured for the specific application prior to delivery.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Ultrasonic transit time velocity measurement utilizing non-wetted transducers matched for the specific application.
4. Design: Flowmeter shall consist of a processor/transmitter, matched pair of transducers and mounting hardware including pipe clamps and mounting bracket for the line size and material specified. When provided with the energy option, the meter is also provided with a matched pair of temperature sensors and temperature thermowells specified for the application.
5. Construction: Selected based on piping material.
6. Minimum Pressure Rating: 150 psig.
7. Minimum Temperature Rating: 180 deg F.
8. Accuracy: Flowmeter and delta temperature shall provide calibrated outputs directly from the transmitter, throughout the operating range with the accuracy stated as follows:
 - a. Plus or minus 1% of rate from 1.0 to 20.0 ft/sec velocity.
 - b. Current (mA) based sensors: NIST traceable differential temperature uncertainty within the calibrated temperature range shall not exceed plus or minus 0.15 deg F.
 - c. RTD sensors: Differential temperature uncertainty within the calibrated temperature range shall not exceed plus or minus 0.18 deg F. RTDs must meet EN1434/CSA C900.1 requirements for 3K sensors.
9. Calibration: Each meter shall be individually calibrated against a NIST traceable standard and receive a certificate of calibration. Each meter shall be factory programmed based on the application data specified at the time of order.
10. Transmitter Enclosure: Transmitter enclosure shall be cast aluminum, IP67 rated.
11. Display: Provide an operator interface consisting of five push-buttons. Display shall visually indicate instantaneous flow rate and total fluid volume. When provided with the energy option, the meter shall also display instantaneous energy rate and temperature data and totalized energy. Output signals shall be RS485 BACnet MS/TP or Modbus RTU native to the transmitter. Two programmable pulse outputs configured for totalizing flow, indicating flow direction, operating mode or alarm status shall also be provided along with a single analog output signal. When provided with the energy option, four (4) additional programmable pulse and two (2) additional analog outputs shall be provided along with three (3) auxiliary pulse inputs for totalization.
12. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

C. Insertion Electromagnetic Flowmeters:

1. Description: Provide an insertion electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, integral transmitter, installation valves,

installation depth gage and calibration certificate. Flowmeter shall be wet tappable, allowing insertion and removal from the flow stream without system shutdown.

2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Electromagnetic velocity-measuring element.
4. Design: Electromagnetic sensing element shall utilize two sets of diametrically opposed electrodes to measure the average flow rate velocity.
5. Construction: Wetted components shall be constructed of 316L stainless steel with attached tag indicating calibration information.
6. Minimum Pressure Rating: 250 psig.
7. Minimum Temperature Rating: 250 deg F.
8. End Connections for NPS 1.25 and Larger: 1" male NPT hot tap adapter fitting.
9. Accuracy: Flowmeter shall provide calibrated outputs directly from the transmitter, throughout the operating range with the accuracy stated as follows:
 - a. Plus or minus 1% of rate from 2.0 to 20.0 ft/sec velocity (10:1 turndown).
 - b. Plus or minus 0.02 ft/s at flow rates < 2 ft/s
10. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard that is traceable to NIST.
11. Transmitter Enclosure: Transmitter enclosure shall be cast aluminum, IP67 rated.
12. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

D. Inline Electromagnetic Flowmeters:

1. Description: Provide an inline electromagnetic flowmeter complete with NIST traceable, wet calibrated flow-measuring element, transmitter, visual display, ANSI Class 150 or 300 mounting flanges, and calibration certificate.
2. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
3. Sensor: Electromagnetic velocity-measuring element.
4. Design: Electromagnetic sensing element shall utilize a minimum of two 316L stainless steel electrodes to measure the average flow rate velocity.
5. Construction: Flowmeter shall consist of epoxy painted carbon steel outer body, 304 stainless steel flow tube and integral liner to be selected based on operating temperature and fluid. Individual calibration tag shall be attached indicating calibration and programming information.
6. Minimum Pressure Rating: 250 psig.
7. Minimum Temperature Rating: 250 deg F.
8. End Connections for NPS 1 and Larger: Flanged.
9. Accuracy: Flowmeter shall provide calibrated outputs directly from the transmitter, throughout the operating range with the accuracy stated as follows:
 - a. Plus or minus 0.2% of rate from 1.6 to 33.0 ft/sec velocity.

- b. Plus or minus 0.0033 ft/s at flow rates < 1.6 ft/s
- 10. Calibration: Each flowmeter shall receive a wet calibration, within the expected operating range, against a primary volumetric standard directly traceable to international standards in accordance with ISO 9104:1991 and ISO 17025:2005.
- 11. Transmitter Enclosure: Transmitter enclosure shall be cast aluminum, IP67 rated.
- 12. Display: Menu driven via three (3) button programming keys and shall include 16 character, 8 line graphic LCD backlit display. Display shall provide instantaneous flow rate information, totalized flow information, flow velocity, flow direction, short term trend data and shall be factory configured for a specific flowmeter application.
- 13. Warranty: Each flowmeter shall be covered by the manufacturer's three-year warranty.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermometers in the following locations and elsewhere as indicated on drawings and details:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. One inlet and one outlet of each evaporative fluid cooler.
 - 3. Inlet and outlet of each hydronic coil in air-handling units/dedicated outdoor air systems.
- B. Install pressure gages in the following locations and elsewhere as indicated on drawings and details:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Inlet and outlet of each evaporative fluid cooler-water connection.
 - 3. Inlet and outlet of each air-handling unit.
 - 4. Suction and discharge of each pump.
 - 5. Inlet and outlet of each strainer.
- C. Install thermowells with socket extending a minimum of 2 inches into fluid or one-third of pipe diameter for pipes 3" and smaller. Install in vertical position in piping tees.
- D. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- E. Install thermowells with extension on insulated piping.
- F. Fill thermowells with heat-transfer medium.
- G. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- H. 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.
- I. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- J. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- K. Install remote-mounted pressure gages on panel.
- L. Install valve and snubber in piping for each pressure gage for fluids (except steam).

- M. Install valve and syphon fitting in piping for each pressure gage for steam.
- N. Install test plugs in piping tees.
- O. Install flow indicators in piping systems in accessible positions for easy viewing.
- P. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- Q. Install flowmeter elements in accessible positions in piping systems.
- R. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- S. Install permanent indicators on walls or brackets in accessible and readable positions.
- T. Install connection fittings in accessible locations for attachment to portable indicators.
- U. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- V. Install flow meters and thermal energy meters where indicated on drawings.

3.2 FLOWMETER SCHEDULE

- A. Flowmeters for Ground Source Heat Pump Piping: Ultrasonic or Electromagnetic type.

3.3 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. All HVAC piping pressure gages shall conform to two times operating pressure.

3.4 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow space for service and maintenance of meters, gages, machines, and equipment.
- B. Connect flowmeter-system elements to meters.
- C. Connect flowmeter transmitters to meters.
- D. Connect thermal-energy meter transmitters to meters.

3.5 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.

END OF SECTION 230519

SECTION 230523 – VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. General Requirements for Valves
 - 2. Angle Valves
 - 3. Globe Valves
 - 4. Ball Valves
 - 5. Butterfly Valves
 - 6. Check Valves
 - 7. Gate Valves
 - 8. Chainwheels

1.2 SUBMITTALS

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

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set angle and globe valves closed to prevent rattling.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Valve, Inc.
 - 2. Milwaukee Valve Company.
 - 3. NIBCO INC.
 - 4. Watts.
- B. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- 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 B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B16.18 for solder joint.
 5. ASME B31.1 for power piping valves.
 6. ASME B31.9 for building services piping valves.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valves in Insulated Piping: With 2-inch stem extensions.
- G. Valve ends shall match connected piping. See Hydronic Piping specification for required joints.

2.2 ANGLE VALVES

A. Bronze Angle Valves:

1. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating:
 - 1) Class 125: 200 psig.
 - 2) Class 150: 300 psig
 - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.
 - e. Stem and Disc: Bronze.
 - f. Handwheel: Malleable iron, bronze, or aluminum.

2.3 GLOBE VALVES

A. Bronze Globe Valves, Class 125:

1. Description:
 - a. Standard:
 - 1) Class 125: MSS SP-80, Type 1.
 - 2) Class 150: MSS SP-80, Type 2.
 - b. CWP Rating:
 - 1) Class 125: 200 psig.
 - 2) Class 150: 300 psig.
 - c. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.

B. Iron Globe Valves, Class 125:

1. Description:

- a. Standard: MSS SP-85, Type I.
- b. CWP Rating:
 - 1) Class 125: 200 psig.
 - 2) Class 250: 500 psig.
- c. Body Material: ASTM A126, gray iron with bolted bonnet.
- d. Ends: Flanged.

2.4 BALL VALVES

A. Bronze Ball Valves with Full Port and Bronze or Brass Trim, Threaded Ends:

- 1. Standard: MSS SP-110.
- 2. SWP Rating: 150 psig
- 3. CWP Rating: 600 psig
- 4. Body Design: Two or three piece.
- 5. Body Material: Bronze.
- 6. Ends: Threaded.

2.5 BUTTERFLY VALVES

A. Iron, Single-Flange (Lug-Type) Butterfly Valves:

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

2.6 CHECK VALVES

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

- 1. Standard: MSS SP-80, Type 1.
- 2. CWP Rating: 200 psig.
- 3. Body Design: Vertical flow.
- 4. Body Material: ASTM B61 or ASTM B62, bronze.
- 5. Ends: Threaded.

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

- 1. Standard: MSS SP-80, Type 3.
- 2. CWP Rating: 200 psig.

3. Body Design: Horizontal flow.
4. Body Material: ASTM B62, bronze.
5. Ends: Threaded.
6. Disc: Bronze.

C. Iron, Grooved-End Swing Check Valves, 300 CWP:

1. CWP Rating: 300 psig.
2. Body Material: ASTM A536, ductile iron.
3. Seal: EPDM.
4. Disc: Spring-operated, ductile iron or stainless steel.

HDPE Ball Check Valves:

5. Pressure Rating and Temperature: 125 psig at 73 deg F
6. Body Material: HDPE.
7. Body Design: Union-type ball check.
8. Ball: HDPE.
9. Seals: EPDM- or FKM-rubber O-rings.

2.7 GATE VALVES

A. Bronze Gate Valves:

1. Standard: MSS SP-80, Type 1.
2. CWP Rating:
 - a. Class 125: 200 psig.
 - b. Class 150: 300 psig.
3. Body Material: ASTM B62, bronze with integral seat and screw-in bonnet.
4. Ends: Threaded.
5. Stem: Bronze.
6. Disc: Solid wedge; bronze.
7. Handwheel: Malleable iron, bronze, or aluminum.

B. Iron Gate Valves, NRS, Class 250:

1. Standard: MSS SP-70, Type I.
2. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
3. NPS 14 to NPS 24, CWP Rating: 300 psig.
4. Body Material: ASTM A126, gray iron with bolted bonnet.
5. Ends: Flanged.
6. Trim: Bronze.
7. Disc: Solid wedge.

C. HDPE Gate Valves:

1. Pressure Rating and Temperature: 125 psig at 73 deg F.
2. Body Material: HDPE.
3. Body Design: Nonrising stem.
4. End Connections for Valves NPS 2 and Smaller: Socket or threaded.
5. End Connections for Valves NPS 2-1/2 to NPS 4: Socket or threaded.
6. Gate and Stem: Plastic.
7. Seals: EPDM rubber.
8. Handle: Wheel.

2.8 CHAINWHEELS

- A. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.
 1. Chain: Hot-dip-galvanized steel or Stainless steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze angle or globe valves, bronze disc, with threaded ends.
- B. Pipe NPS 2-1/2 and Larger: Iron globe valves, with flanged ends.
- C. HDPE pipe going to well field: HDPE angle or globe valves with flanged ends.
- D. General: Value shown is ANSI class unless value is followed by "CWP" which indicates cold working pressure rating.
 1. VALVES, 2-INCH AND SMALLER

SERVICE	GATE	GLOBE	BALL	CHECK
GSHP System Water	125	125	150	125]

2. VALVES, 2-1/2-INCH AND LARGER

SERVICE	GATE	GLOBE	BALL	BUTTERFLY	CHECK
GSHP System Water	125	125	150	200CWP	125

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

3.2 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.

3.3 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 globe valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.
- F. 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.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING, DUCTWORK, AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Pipe hangers and supports
 - 2. Duct hangers and supports
 - 3. Equipment hangers and supports

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Include design calculations for designing trapeze hangers.

1.3 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code, Section IX.
- C. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

PART 2 - PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Armacell.
 - 2. Anvil International.
 - 3. Cooper B-Line, Inc.
 - 4. Halfen-DEHA.
 - 5. Hilti.
 - 6. ERICO\Michigan Hanger Co.
 - 7. National Pipe Hanger Corporation.
 - 8. Phillips
 - 9. Power-Strut.
 - 10. Rooftop Blox.
 - 11. Unistrut.

- B. Hangers and support components shall be factory fabricated of materials, design, and manufacturer complying with MSS SP-58.
 - 1. Components shall have galvanized coatings where installed for piping and equipment that will not have factory applied or field-applied finish.
 - 2. Pipe attachments shall be copper-plated or have nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
 - 3. Components as listed below shall be made of 304 stainless steel where installed in corrosive environments and/or where indicated on the drawings.
- C. Thermal-hanger shield inserts
 - 1. Insulation-Insert Material for Cold Piping: ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength and vapor barrier.
 - 2. Insulation-Insert Material for Hot Piping: Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi ASTM C552, Type II cellular glass with 100-psi, or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
 - 3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
 - 4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
 - 5. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.
- D. Pipe stands
 - 1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
 - 2. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 3. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 4. Hardware: Galvanized steel or polycarbonate.
 - 5. Accessories: Protection pads.
- E. Manufacturer Metal Framing Systems:
 - 1. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
 - 2. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 3. Channels: Continuous slotted carbon-steel, stainless-steel, Type 304 stainless-steel, or Type 316 extruded-aluminum channel with intumed lips.
 - 4. Channel Width: Selected for applicable load criteria.
 - 5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

- F. Mechanical-Expansion Anchors: Insert-wedge-type anchors, for use in hardened portland cement concrete, with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Indoor Applications: Zinc-coated or stainless steel.
 - 2. Outdoor Applications: Stainless steel.
- G. Pipe-Positioning Systems
 - 1. Description: IAPMO PS 42 positioning system composed of metal brackets, clips, and straps for positioning piping in pipe spaces; for plumbing fixtures in commercial applications.

2.2 DUCT HANGERS AND SUPPORTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armacell.
 - 2. Anvil International.
 - 3. Cooper B-Line, Inc.
 - 4. Halfen-DEHA.
 - 5. Hilti.
 - 6. ERICO\Michigan Hanger Co.
 - 7. McGill AirFlow LLC.
 - 8. MKT Metal Manufacturing.
 - 9. National Pipe Hanger Corporation.
 - 10. Power-Strut.
 - 11. SHAPE Manufacturing Inc.
 - 12. Sheet Metal Connectors, Inc
 - 13. Unistrut.
- B. Hanger Rods for Noncorrosive Environments: Galvanized-steel rods and nuts.
- C. Strap and Rod Sizes: 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."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A492.
- F. Steel Cable End Connections: Galvanized-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.

2.3 EQUIPMENT HANGERS AND SUPPORTS

- A. Subject to compliance with requirements, provide products by one of the following for each equipment type:
 1. Custom Curb, Inc.
 2. Pate Company.
 3. Thybar.
- B. Indoor equipment stands
 1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.
- C. Outdoor equipment stands
 - a. Description: Individual foot supports with elevated adjustable channel cross bars and clamps/fasteners/bolts for ground or roof supported outdoor equipment components, without roof membrane penetration, in a pre-fabricated system that can be modularly-assembled on site.
 - b. Foot Material: Rubber or polypropylene.
 - c. Rails Material: Hot dip galvanized carbon steel.
- D. Materials
 1. Aluminum: ASTM B221.
 2. Carbon Steel: ASTM A1011/A1011M.
 3. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
 4. Stainless Steel: ASTM A240/A240M.
 5. Threaded Rods: Continuously threaded. Zinc-plated or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar materials as rods.
 6. Grout: ASTM C1107/C1107M, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - a. Properties: Nonstaining, noncorrosive, and nongaseous.
 - b. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. 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 PIPING HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: 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. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled strut systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Use thermal hanger-shield insert with clamp sized to match OD of insert.
 - b. 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.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- F. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- G. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.
- H. Pipe-Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- I. Install hangers and supports to allow controlled thermal 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.

- J. Install lateral bracing with pipe hangers and supports to prevent swaying.
- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. 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 DUCT HANGERS AND SUPPORTS

- A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- B. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. 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.
- E. 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.

3.4 EQUIPMENT SUPPORTS

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

3.5 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.

3.6 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.

3.7 PAINTING

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

END OF SECTION 230529

SECTION 230550 - VIBRATION CONTROLS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vibration isolation for piping, ductwork and equipment.

1.2 SUBMITTALS

A. Descriptive Data:

1. Schedules of flexibly mounted equipment, referencing drawings by number.
2. Catalog cuts or data sheets on vibration isolators.

B. Drawings:

1. Submit details of equipment bases including dimensions, structural member sizes and support point locations.
2. Submit details of isolation hangers for ceiling hung equipment, piping and ductwork.
3. Submit details of mountings for floor supported equipment, piping and ductwork.
4. All hanger, mounting or pad drawings shall indicate deflections and model numbers as well as any other requirements in the specifications.
5. Spring diameters, rated loads and deflections, heights at rated load and closed height shall be provided for all springs shown in the submittals in tabular form.
6. Complete flexible connector details.

C. Wind Certification and Analysis:

1. Wind restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.
2. Analysis must indicate calculated dead loads, static wind loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All wind restraint devices shall be designed to accept, without failure, the forces resulting from.

1.3 WIND FORCE REQUIREMENTS

A. The wind forces used on this project are based on the ASCE 7.

1. Occupancy Category = IV
2. Velocity in miles per hour, $V = 122$
3. Importance factor, $I = 1.5$

1.4 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

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

- A. Mason Industries, Inc.
- B. Vibration Eliminator Co., Inc.
- C. Vibro-Acoustics.

2.2 VIBRATION ISOLATION FOR PIPING, DUCTWORK AND EQUIPMENT

- A. Type A: Neoprene mountings shall have a minimum static deflection of 0.35. All metal surfaces shall be neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang.
- B. Type B: Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection.
- C. Type C: Equipment with large variations in the operating and installed weight, such as chillers, boilers, etc., and equipment exposed to the wind such as cooling towers, roof mounted fans and roof mounted air handling equipment shall be mounted on spring mountings, including the neoprene acoustical pad within a rigid sided housing that includes vertical limit stops to prevent spring extension when weight is removed and temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection. When the equipment is at full operating weight, the springs shall be adjusted to assume the weight and the spacers removed, without changing the installed and operating heights. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as horizontal modes. The hole through the bushing shall be a minimum of 0.75" larger in diameter than the restraining bolt. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of 0.5" to avoid bumping and interfering with the spring action. Vertical limit stops shall be out of contact during normal operation. Cooling tower mounts are to be located between the supporting steel and the roof or the grillage and dunnage as shown on the drawings when there is no provision for direct mounting. Housings and springs shall be powder coated and hardware electro galvanized.
- D. Type D: Hangers shall consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring.
- E. Type E: Hangers shall be pre-compressed and locked at the rated deflection by means of a resilient up stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale.
- F. Type F: Hangers shall be manufactured with minimum characteristics as in Type B, but without the neoprene element. Springs are seated in a steel washer reinforced neoprene cup that has a

neoprene bushing projecting through the bottom hole to prevent rod to hanger contact. Spring diameters and the lower hole sizes, shall be large enough to allow the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing.

1. If ducts are suspended by flat strap iron, the hanger assembly shall be modified by the manufacturer with an eye on top of the box and on the bottom of the spring hanger rod to allow for bolting to the hanger straps.
- G. Type G: When total air thrust exceeds 10% of the isolated weight, floor mounted or suspended air handling equipment shall be protected against excessive displacement by the use of horizontal thrust restraints. The restraint shall consist of a modified spring mounting. Restraint springs shall have the same deflection as the isolator springs. The assembly shall be preset at the factory and fine tuned in the field to allow for a maximum of 1/4" movement from stop to maximum thrust. The assemblies shall be furnished with rod and angle brackets for attachment to both the equipment and duct work or the equipment and the structure. Restraints shall be attached at the center line of thrust and symmetrically on both sides of the unit.
- H. Type H: Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped. Pump bases for split case pumps shall be large enough to support suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1".
- I. Type I: Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating concrete bases. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6". The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable.
- J. Type J: Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the roof curb and under the isolated equipment. The extruded aluminum top member shall overlap the bottom to provide water runoff independent of the seal. Aluminum members shall house electro galvanized or powder coated springs selected for 0.75" minimum deflection. Travel to solid shall be 1.5" minimum. Spring diameters shall be no less than 0.8 of the spring height at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4" so as not to interfere with the spring action except in high winds. Manufacturer's self adhering closed cell sponge gasketing must be used both above and below the base and a flexible EPDM duct like connection shall seal the outside perimeter. Foam or other sliding or shear seals are unacceptable in lieu of the EPDM duct like closure.
- K. Type K: Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware must be plated and the springs provided with a

rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" of insulation.

- L. Type L: Rooftop equipment that is not designed for curbs shall be mounted on independent spring isolated rail. The rails shall have a lower structural load distribution member supporting adjustable and removable rust resistant steel springs under a floating upper section that provides continuous support for the equipment. The upper section must be restrained by all directional snubber to resist wind forces. The lower rail section shall have provision for 1-1/2" of insulation. All weather resistant springs must be laterally stable and rest on 1/4" neoprene acoustical pads. Hardware must be plated and the entire assembly furnished with continuous aluminum or galvanized flashing. All parts requiring adjustment must remain accessible thru a sealed port. Equipment must be adequately fastened to the rails and the lower section of the rails similarly anchored to the roof structure. Wind restraint calculations must follow load path.
- M. Type M: Rubber expansion joints shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 16" through 24" may be single sphere. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.
 - 1. Minimum ratings through 14" shall be 250psi at 170°F and 215psi at 250°F., 16" through 24" 180psi at 170°F and 150psi at 250°F. Higher published rated connectors may be used where required.
 - 2. Safety factors shall be a minimum of 3/1. All expansion joints must be factory tested to 150% of maximum pressure for 12 minutes before shipment.
 - 3. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them. Minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves.
- N. Type N: Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes may have male nipples. At equipment, hoses shall be installed on the equipment side of the shut off valves horizontal and parallel to the equipment shafts wherever possible. Minimum lengths shall be as tabulated:

NPS	in	Flanged Live Length in	Threaded End to End in	Threaded Live Length in	Grooved End to End in	Grooved Live Length in	Copper Sweat Bronze End to End in	Copper Sweat Bronze Live Length in	Min Convolutions Per 1 foot
1/2	-	-	24	19-3/4	-	-	18	14-1/4	92
3/4	-	-	24	19-3/4	-	-	18	13-3/4	80
1	-	-	24	19-3/4	-	-	18	13-3/8	72
1-1/4	-	-	24	18-3/4	-	-	18	13-1/4	67
1-1/2	24	21-7/8	24	18-3/4	-	-	18	13	63
2	24	21-1/8	24	18	24	18	18	12-1/2	58
2-1/2	24	21-1/8	24	17	24	18	18	10-3/4	48
3	36	33-1/8	36	29	36	30	18	10-1/2	46
4	36	33-1/8	36	29	36	28	24	15-1/2	32
5	36	32-7/8	-	-	36	28	-	-	29
6	36	32-7/8	-	-	36	28	-	-	25
8	36	32-5/8	-	-	36	28	-	-	23
10	36	32-5/8	-	-	36	26	-	-	21
12	36	32-5/8	-	-	36	26	-	-	20

14	36	32-5/8	-	-	-	-	-	-	18
16	36	32-5/8	-	-	-	-	-	-	16

- O. Type O: Split Seals consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not in place prior to the construction of the building member. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240 deg F, 10 lb. density fiberglass may be used in lieu of the sponge.
- P. Type P: All directional acoustical pipe anchors, consist of two sizes of steel tubing separated by a minimum 1/2" thickness of 60 duro or softer neoprene. Vertical restraint shall be provided by similar material arranged to prevent up or down vertical travel. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction.
- Q. Type Q: Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of 60 durometer or softer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Guides shall be capable of $\pm 1\text{-}5/8"$ motion, or to meet location requirements.

PART 3 - EXECUTION

3.1 Schedules:

- A. Hangers supporting piping 2" and larger in all locations throughout the building shall be isolated by Type D hangers. Floor supported piping shall rest on Type C isolators. Heat exchangers and expansion tanks are considered part of the piping run. The first four isolators from the isolated equipment shall have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces, the first four hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1-1/2" deflection for pipe sizes over 3" and up to and including 6", and 2-1/2" deflection thereafter. Where piping connects to mechanical equipment, install Type M expansion joints or Type N stainless hoses if Type M is not suitable for the service. All piping passing through the equipment walls, floors or ceilings shall be protected against sound leakage by means of a Type O acoustical seal, as described in.
- B. All air ducts with a cross section of 2'-2" or larger shall be isolated from the building structure by Type F hangers or Type B floor supports with a minimum deflection of 0.75". Isolators shall continue for 50' from the equipment. If air velocity exceeds 1000 fpm, hangers or supports shall continue for an additional 50' or as shown on the drawings.

Base Mounted Equipment	On Grade		Above grade	
	Spec Type	Min Deflection	Spec Type	Min. Deflection
AHU (DOAS)-with internal isolation	A, G, H, M	0.30"	A, G, H, M	0.30"
Evaporative Fluid Cooler	C, M	1"	C, M	3"

CRAC Fluid Cooler	A	0.30"	A	0.30"
Computer Room AC unit	A	0.30"	A	0.30"
Pump-Vertical Inline	B, J, M	1"	B, J, M	2"
Ground Source Heat Pump	A	0.30"	A	0.30"

Suspended Equipment	Above grade	
	Mount Type	Min. Deflection
Air Curtin	A	0.30"
Fan	D	1"
Pump inline	D	2"
Water Source Heat Pump	D	1"

Deflection Guide	
RPM	Min Deflection
<400	3.50"
<600	2.50"
>600	1.50"

3.2 GENERAL

- A. All vibration isolators must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.
- C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.
- D. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.
- E. Bring to the architects/engineers attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.
- F. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.
- G. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24" or specified movements exceed Type M capabilities.

- H. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide Type O seals.
- I. Locate isolation hangers as near to the overhead support structure as possible.
- J. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust when thrust forces exceed 10% of the equipment weight. Horizontal thrust restraints shall be Type G restraints.
- K. Rooftop equipment isolators must be bolted to the equipment and structure. Mountings must be designed to resist specified wind loads.

3.3 VIBRATION ISOLATION OF PIPING

- A. Horizontal pipe shall be installed in accordance with schedule.
- B. Risers shall be installed in accordance with schedule.

3.4 VIBRATION ISOLATION OF DUCTWORK

- A. All duct runs shall be installed in accordance with schedule.

END OF SECTION 230550

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Warning tape.
4. Pipe labels.
5. Duct labels.
6. Stencils.
7. Valve tags.
8. Warning tags.

1.2 SUBMITTALS

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

1.3 SPARE PARTS

- A. Furnish minimum of 5% extra stock of each plumbing identification material required, including additional numbered valve tags (not less than 3) for each piping system, additional piping system identification markers, and additional plastic laminate engraving blanks of assorted sizes.
1. Where stenciled markers are provided, clean and retain stencils after completion of stenciling and include used stencils in extra stock, along with required stock of stenciling paints and applicators.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. General: Provide manufacturer's standard laminated plastic, color coded equipment markers
- B. Size: Provide 2-1/2" x 4" markers for control devices, dampers, and valves; and 4-1/2" x 6" for equipment.
- C. Metal Labels for Equipment:
1. Material and Thickness: 0.32-inch minimum thickness, brass, stainless steel, aluminum, or anodized aluminum, with predrilled or stamped holes for attachment hardware.
 2. Letter and Background Color: As indicated for specific application under Part 3.
 3. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 4. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 5. Fasteners: Stainless steel rivets or self-tapping screws.

6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

D. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
2. Letter and Background Color: As indicated for specific application under Part 3.
3. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
6. Fasteners: Stainless steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- E. Label Content: Include equipment's Drawing designation or unique equipment number, drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.

2.2 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, with predrilled holes for attachment hardware.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Maximum Temperature: Able to withstand temperatures of up to 160 deg F.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- F. Fasteners: Stainless steel rivets or self-taping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Label Content: Include caution and warning information plus emergency notification instructions.

2.3 WARNING TAPE

- A. Material: Vinyl.
- B. Minimum Thickness: 0.005 inch.
- C. Letter, Pattern, and Background Color: As indicated for specific application under Part 3.
- D. Waterproof Adhesive Backing: Suitable for indoor or outdoor use.
- E. Maximum Temperature: 160 deg F.
- F. Minimum Width: 4 inches.

2.4 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color coded, with lettering indicating service and showing flow direction in accordance with ASME A13.1.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover or cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings. Also include:
 - 1. Pipe size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution piping. Arrows may be either integral with label or applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.5 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter and Background Color: As indicated for specific application under Part 3.
- C. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- D. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- E. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances of up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- F. Fasteners: Stainless steel rivets or self-tapping screws.
- G. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- H. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings. Also include the following:
 - 1. Duct size.
 - 2. Flow-Direction Arrows: Include flow-direction arrows on main distribution ducts. Arrows may be either integral with label or may be applied separately.
 - 3. Lettering Size: Size letters in accordance with ASME A13.1 for piping.

2.6 STENCILS

- A. Lettering Size:
 - 1. Piping: Size letters in accordance with ASME A13.1 for piping.
 - 2. Ducts: Minimum letter height of 1-1/4 inches for viewing distances of up to 15 ft. and proportionately larger lettering for greater viewing distances.

3. Access Panels and Door Labels, Equipment Labels: Minimum letter height of 1/2 inch for viewing distances of up to 72 inches and proportionately larger lettering for greater viewing distances.
 - B. Stencil Material: Aluminum, brass, or fiberboard.
 - C. Stencil Paint: Exterior, gloss, alkyd enamel or acrylic enamel in colors complying with recommendations in ASME A13.1 unless otherwise indicated. Paint may be in pressurized spray-can form.
 - D. Identification Paint: Exterior, alkyd enamel or acrylic enamel. Paint may be in pressurized spray-can form.
 - E. Letter and Background Color: As indicated for specific application under Part 3.
- 2.7 VALVE TAGS
- A. Description: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 1. Tag Material: Brass, 0.04-inch minimum thickness, with predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass beaded chain
 - B. Letter and Background Color: As indicated for specific application under Part 3.
 - C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 1. Include valve-tag schedule in operation and maintenance data.
- 2.8 WARNING TAGS
- A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 1. Size: 3 by 5-1/4 inches minimum.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption, such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Letter and Background Color: As indicated for specific application under Part 3.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL REQUIREMENTS

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.
- D. Locate identifying devices so that they are readily visible from the point of normal approach.

3.2 INSTALLATION

- A. Permanently fasten labels on each item of mechanical equipment including:

1. Main control and operating valves, including safety devices and hazardous units such as gas outlets.
2. Meters, gauges, thermometers and similar units.
3. Fuel-burning units including boilers, furnaces, heaters, stills and absorption units.
4. Pumps, compressors, chillers, condensers and similar motor- driven units.
5. Heat exchangers, coils, evaporators, cooling towers, heat recovery units and similar equipment.
6. Fans, blowers, primary balancing dampers, mixing boxes and air terminal units.
7. Variable frequency drives.
8. Packaged HVAC central-station or zone-type units.
9. Electric heaters and terminal heating and cooling units.
10. Tanks and pressure vessels.
11. Strainers, filters, humidifiers, water treatment systems and similar equipment.

B. Ductwork

1. Identify supply, return, exhaust, outdoor and relief air ductwork with duct markers; or provide stenciled signs and arrows in concealed locations, showing ductwork service and direction of flow.
2. Location: Provide duct markers where ductwork is exposed to view, concealed only by a removable ceiling system, located in accessible maintenance spaces (shafts, tunnels, etc), and located in exterior non-concealed locations as follows:
3. Within 5 feet of each control damper or balancing damper, excluding balancing dampers installed in duct take-offs to grilles, registers or diffusers that are less than 25 feet in lengths and installed in the same space as the air device.
4. Within 5 feet of each branch duct, excluding branch ducts that are less than 25 feet in length and located in the same space as the main duct.
5. Within 5 feet of locations where ducts pass through walls, floors or ceilings or enter non-accessible enclosures. Provide identification on each side of the wall, floor and ceiling.
6. Spaced intermediately at a maximum spacing of 50 feet along each duct run, except reduce spacing to 25 feet in congested areas when there are more than two types of ductwork systems or more than three pieces of equipment.
7. Within 5 feet of equipment and other points of origin or termination.
8. Install marker on the most obviously visible portion of the duct from point of access.

C. Access Doors: Provide duct markers or stenciled signs in concealed locations on each access door in ductwork and housings, indicating purpose of access (to what equipment) and other maintenance and operating instructions, and appropriate safety and procedural information.

D. 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.

E. Locate equipment labels where accessible and visible.

- F. Install warning tape on pipes with cross-designated walkways providing less than 6 ft. of clearance.
- G. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
 - 1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
 - 2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.
- H. Locate tape to be readily visible from the point of normal approach.
- I. Install pipe labels showing service and flow direction with permanent adhesive on pipes.
- J. Stenciled Pipe Label Option: Stenciled labels showing service and flow direction may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- K. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Within 3 ft. of each valve and control device.
 - 2. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 3. Within 3 ft. of equipment items and other points of origination and termination.
 - 4. Spaced at maximum intervals of 50 ft. along each run. Reduce intervals to 10 ft. in areas of congested piping and equipment.
- L. Do not apply plastic pipe labels or plastic tapes directly to bare pipes conveying fluids at temperatures of 125 deg F or higher. Where these pipes are to remain uninsulated, use a short section of insulation or use stenciled labels.
- M. Flow-Direction Flow Arrows: Use arrows, in compliance with ASME A13.1, to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- N. Install tags on valves and control devices in piping systems, except check valves, valves within factory-fabricated equipment units, shutoff valves, and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule in the operating and maintenance manual.
 - 1. Valve-Tag Size and Shape: 2 inches, round or square.
- O. Install plastic-laminated or self-adhesive duct labels showing service and flow direction with permanent adhesive on air ducts.
- P. Stenciled Duct-Label Option for concealed duct only: Stenciled labels showing service and flow direction may be provided instead of plastic-laminated duct labels, at Installer's option.
- Q. Locate duct label near each point where ducts enter into and exit from concealed spaces and at maximum intervals of 20 ft. where exposed or are concealed by removable ceiling system.

R. Attach warning tags, with proper message, to equipment and other items where indicated on Drawings.

S. Colors

1. Equipment, Refrigerant Piping, and Compressed Air Piping: White letters, safety-blue background.
2. Chilled-Water Piping, Condenser-Water Piping, Heating Water Piping, and Potable Water: White letters, safety-green background.
3. Combustible Fluids: White letters, safety-brown background.
4. Toxic and Corrosive Fluids: Black letters, safety-orange background.
5. Low-Pressure Steam Piping, High-Pressure Steam Piping, and Steam Condensate Piping: Black letters, safety-yellow background.
6. Warning Tape: Yellow background with black diagonal stripes.
7. Flammable Fluids and Warning Tag: Black letters, safety-yellow background.
8. Duct Labels: White letters, blue background.
 - a. Stenciled for all concealed air ducts: Black letters, white background.
9. Stenciled for all concealed access panels, door labels, and equipment labels: Black letters, white background.

3.3 PREPARATION

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

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Testing, adjusting, and balancing of HVAC equipment.
2. Testing, adjusting, and balancing of Air Systems.
3. Testing, adjusting, and balancing of Hydronic Piping Systems.
4. Duct and pipe leakage tests verification.
5. UFAD plenum leakage tests verification.
6. HVAC-control system verification.
7. Tolerances
8. Final testing, adjusting, and balancing report
9. Verification of testing, adjusting, and balancing.

1.2 SUBMITTALS

- A. Qualification Data: Submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article. Coordinate submission date with general contractor.
- B. Contract Documents Examination Report: Submit the Contract Documents review report, as specified in Part 3. Coordinate submission date with general contractor.
- C. Strategies and Procedures Plan: Submit TAB strategies and step-by-step procedures, as specified in "Preparation" Article. Coordinate submission date with general contractor.
- D. System Readiness Checklists: Submit system readiness checklists, as specified in "Preparation" Article. Coordinate submission date with general contractor.
- E. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- F. Certified TAB reports.
- G. Instrument calibration reports, to include the following:
1. Instrument type and make.
 2. Dates of calibration.

1.3 QUALITY ASSURANCE

A. Provide one of the following qualifications:

1. TAB Specialists Qualifications, Certified by AABC:
 - a. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC.
2. TAB Specialists Qualifications, Certified by NEBB:
 - a. TAB Field Supervisor: Employee of the TAB specialist and certified by NEBB.

- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."
- D. Code and AHJ Compliance: TAB is required to comply with governing codes and requirements of authorities having jurisdiction.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements of general contractor's approved TAB specialists.

3.2 EXAMINATION

- A. Examine installed systems for balancing devices, such as test ports, gauge cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- B. Examine the approved submittals for HVAC systems and equipment.
- C. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- D. Examine temporary and permanent strainers. Verify that temporary strainer screens used during system cleaning and flushing have been removed and permanent strainer baskets are installed and clean.
- E. Examine control valves for proper installation for their intended function of isolating, throttling, diverting, or mixing fluid flows.
- F. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- G. Examine system pumps to ensure absence of entrained air in the suction piping.
- H. Examine operating safety interlocks and controls on HVAC equipment.
- I. Examine control dampers for proper installation for their intended function of isolating, throttling, diverting, or mixing air flows.
- J. 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.
- 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. Coils are connected and free of debris.
 - f. Fans are operating, free of vibration, and rotating in correct direction.
 - g. Variable-frequency controllers' startup is complete and safeties are verified.
 - h. Automatic temperature-control systems are operational.
 - i. Ceilings are installed.
 - j. Windows and doors are installed.
 - k. Suitable access to balancing devices and equipment is provided.
2. Hydronics:
- a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning in accordance with the sequence of operation.
 - g. Shutoff and balance valves have been verified to be 100 percent open.
 - h. Pumps are started and proper rotation is verified.
 - i. Pump gauge connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - j. Variable-frequency controllers' startup is complete and safeties are verified.
 - k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system in accordance with the procedures contained in AABC's "National Standards for Total System Balance", or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.
- B. Cut insulation, ducts, pipes, and equipment casings for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Where holes for probes are required in piping or hydronic equipment, install pressure and temperature test plugs to seal systems.

3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish.
 - 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 TESTING, ADJUSTING, AND BALANCING OF HVAC EQUIPMENT
- A. Test, adjust, and balance HVAC equipment indicated on drawings, including, but not limited to, the following:
 1. HVAC Fans.
 2. Hydronic Systems.
 3. Motors.
 4. Evaporative fluid coolers.
 5. Fluid cooler Condensing Units.
 6. Water Source Heat Pumps.
 7. Unit heaters.
 8. Dedicated outdoor-air units.
 9. Energy-recovery units.
 10. Range hoods
 11. Heat pumps.
 12. Humidifiers.
 13. Air curtains.
 14. Computer-room air conditioners.
- 3.6 GENERAL PROCEDURES FOR BALANCING HVAC FANS
- A. Prepare test reports for all equipment and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
 - B. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
 - C. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 - D. Verify that motor starters are equipped with properly sized thermal protection.
 - E. Check dampers for proper position to achieve desired airflow path.
 - F. Check for airflow blockages.
 - G. Measure total airflow.
 - H. Measure fan static pressures.
 - I. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.

- J. Obtain approval from Architect and Construction Manager 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.
 - 1. 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.
- K. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
- L. Adjust air inlets and outlets for each space to indicated airflows.
- M. Verify final system conditions.
- N. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, pipes, and other equipment as outlined in the reference standards. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and equipment flow rates with pump design flow rate.
- B. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 - 1. Check expansion tank for proper setting.
 - 2. Check highest vent for adequate pressure.
 - 3. Check flow-control valves for proper position.
 - 4. Locate start-stop and disconnect switches, electrical interlocks, and motor controllers.
 - 5. Verify that motor controllers are equipped with properly sized thermal protection.
 - 6. Check that air has been purged from the system.
- C. Measure and record upstream and downstream pressure of each piece of equipment.
- D. Measure and record upstream and downstream pressure of pressure-reducing valves.
- E. Check settings and operation of automatic temperature-control valves, self-contained control valves, pressure-reducing valves, and safety valves. Record final settings.
- F. Adjust pumps to deliver total design flow.
- G. Adjust flow-measuring devices installed in mains and branches to design water flows.
- H. Adjust flow-measuring devices installed at terminals for each space to design water flows.
- I. 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.
- J. 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.
- K. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.
- L. Verify that the pressure-differential sensor(s) is located as indicated.
- M. Balance the primary circuit flow first. Balance the secondary circuits after the primary circuits are complete.
- N. Verify final system conditions.
- O.** Verify that memory stops have been set.
- 3.8 PROCEDURES FOR MOTORS
- A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Phase and hertz.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter size and thermal-protection-element rating.
 8. Service factor and frame size.
- B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.
- 3.9 PROCEDURES FOR EVAPORATIVE FLUID COOLERS
- A. Closed-Circuit Cooling Towers: Balance total condenser-water flows to towers and cells. Measure and record the following data:
1. Condenser-water flow to each cell of the cooling tower.
 2. Pressure drop through each cell.
 3. Entering- and leaving-water temperatures.
 4. Wet- and dry-bulb temperatures of entering and leaving air.
 5. Condenser-water flow rate recirculating through the cooling tower.
 6. Cooling-tower spray pump discharge pressure.
 7. Condenser-water flow through bypass.
 8. Makeup-water flow rate and temperature.
 9. Fan, motor, and motor controller operating data.

3.10 PROCEDURES FOR FLUID COOLER CONDENSING UNITS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Measure and record entering and leaving refrigerant pressures.
- D.** Measure and record operating data of fan(s), and motors.

3.11 PROCEDURES FOR WATER SOURCE HEAT PUMPS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by main Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses close to the fan and prior to any outlets, to obtain total airflow.
 - c. Where duct conditions are unsuitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Contractor-prepared shop drawings and Record drawings to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.

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

3.12 PROCEDURES FOR DOAS UNITS

- 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 outside air connection that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the air volume matches the water source heat pump schedule.
 4. Calibrate and balance each outside air connection to design airflow.
 5. After connections 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.
 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.
 8. Re-measure the inlet static pressure at the most critical terminal unit, and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls Contractor.
 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.

- c. Re-measure final fan operating data, speed, volts, amps, and static profile.
- d. Mark final settings.
- e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
- f. Verify tracking between supply and return fans.

3.13 PROCEDURES FOR ELECTRIC HEATING COILS

- A. Measure, adjust, and record the following data for each electric heating coil:
 - 1. Nameplate data.
 - 2. Airflow.
 - 3. Entering- and leaving-air temperature at full load.
 - 4. Air pressure drop.
 - 5. Voltage and amperage input of each phase at full load.
 - 6. Calculated kilowatt at full load.
 - 7. Fuse or circuit-breaker rating for overload protection.

3.14 PROCEDURES FOR ELECTRIC UNIT HEATERS

- A. Verify proper rotation of fan(s).
- B. Measure and record entering- and leaving-air temperatures.
- C. Voltage and amperage input of each phase at full load.
- D. Calculated kilowatt at full load.
- E. Fuse or circuit-breaker rating for overload protection.

3.15 PROCEDURES FOR RANGE HOODS

- A. Exhaust Hoods: Measure and record the following:
 - 1. Pressure drop across hood.
 - 2. Airflow by duct traverse where duct distribution will allow accurate measurement, and calculate hood average face velocity.
 - 3. Measure velocity across hood face and calculate hood airflow.

3.16 DUCT AND PIPE LEAKAGE TESTS

- A. Witness the leakage testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.17 UFAD PLENUM LEAKAGE TESTS

- A. Witness the UFAD plenum pressure testing performed by Installer.
- B. Verify that proper test methods are used and that leakage rates are within specified limits.
- C. Report deficiencies observed.

3.18 HVAC CONTROLS VERIFICATION

- A. In conjunction with system balancing, perform the following:
 - 1. Verify HVAC control system is operating within the design limitations.
 - 2. Confirm that the sequences of operation are in compliance with Contract Documents.
 - 3. Verify that controllers are calibrated and function as intended.
 - 4. Verify that controller set points are as indicated.
 - 5. Verify the operation of lockout or interlock systems.
 - 6. Verify the operation of valve and damper actuators.
 - 7. Verify that controlled devices are properly installed and connected to correct controller.
 - 8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
 - 9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.
- B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.19 TOLERANCES

- A. Set HVAC system's airflow rates [**and water flow**] rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 10 percent or minus 5 percent. If design value is less than 100 cfm, within 10 cfm.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent. If design value is less than 100 cfm, within 10 cfm.
 - 3. Ground Source Heat Pump and Condenser Water Flow Rate: Plus 10 percent or minus 5 percent. If design value is less than 10 gpm, within 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.20 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Certify validity and accuracy of field data.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Air-Terminal-Device Reports.
 - 4. System-Coil Reports.

5. Test and Balance results from all equipment listed in Part 3 of this specification.
 6. Field test reports prepared by system and equipment installers.
 7. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and location of traverse.
- D. Pump Test Reports.
- 3.21 VERIFICATION OF TAB REPORT
- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
 - B. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to the lesser of either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 - C. 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."
 - D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the TAB shall be considered incomplete and shall be rejected.
 - E. If recheck measurements find the number of failed measurements noncompliant with requirements indicated, proceed as follows:
 1. TAB specialists shall 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. All changes shall be tracked to show changes made to previous report.
- 3.22 ADDITIONAL TESTS
- A. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.
- END OF SECTION 230593

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulating the following HVAC items:

1. Ductwork
2. HVAC Piping
3. HVAC Equipment

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).

1.3 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation system materials are to be delivered to the Project site in unopened containers. Insulation material containers are to be marked with the manufacturer's name, appropriate ASTM standard designation, type and grade, and maximum use temperature.
- B. Insulation that has become waterlogged, as deemed by the owner or engineer, shall not be used. Insulation shall remain in packaged until ready to be used and shall be protected from water, mold, and pests throughout the construction process.

1.4 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

1.5 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products in accordance with ASTM E84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation, jacket materials, adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.
1. All Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
- B. Products that come in contact with stainless steel have a leachable chloride content of less than 50 ppm when tested in accordance with ASTM C871.
- C. Insulation materials for use on austenitic stainless steel are qualified as acceptable in accordance with ASTM C795.
- D. Products shall not contain asbestos, formaldehyde, lead, mercury, or mercury compounds.
- E. Insulation Materials:
1. Comply with ASTM C411.
- F. Mastics and Coatings:
1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
- G. Sustainability Requirements

1. Fiberglass insulations shall have a bio-based, formaldehyde-free binder and be UL GREENGUARD Gold certified.
2. Fiberglass insulations shall have a minimum of 50 percent recycled glass content; certified and validated in accordance with UL 2809 Environmental Claim Validation Procedure for Recycled Content.
3. Fiber glass insulations shall be constructed of Bio-soluble certified by EUCB.
4. Elastomeric insulation shall be formaldehyde-free, GREENGUARD Gold Certified.
5. Sealants and Adhesives shall be GREENGUARD Gold certified.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials are to be applied.
- B. Duct Wrap: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 250 deg F in accordance with ASTM C411. Comply with ASTM C665, ASTM 1338, and ASTM C1617, with factory-applied jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Certainteed; SAINT-GOBAIN.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Owens Corning.
- C. Flexible Elastomeric: Closed-cell or expanded-rubber materials; suitable for maximum use temperature between minus 70 deg F and 220 deg F. Comply with ASTM C534, Type II for sheet materials.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA.
 - b. Armacell North America.
 - c. K-Flex USA.
- D. Glass-Fiber Board Insulation: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 150 deg F for jacketed and between 35 deg F and 450 deg F for unfaced in accordance with ASTM C411. Comply with ASTM C612, Type IA or Type IB. For duct and plenum applications, provide insulation.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Knauf Insulation
 - c. Manson Insulation Inc.

- d. Owens Corning.
 - E. Mineral Wool Board: Basalt volcanic rock-derived fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1100 deg F. Comply with ASTM C612, Type III, unfaced.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - F. Glass-Fiber, Pipe and Tank: Glass fibers bonded with a thermosetting resin; suitable for maximum use temperature between 35 deg F and 850 deg F. Comply with ASTM C1393.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Certainteed; SAINT-GOBAIN
 - b. Johns Manville; a Berkshire Hathaway company
 - c. Knauf Insulation
 - d. Manson Insulation Inc.
 - e. Owens Corning
 - 2. Semirigid board material with factory-applied ASJ jacket.
 - G. Mineral Wool, Pipe and Tank: Mineral wool fibers bonded with a thermosetting resin; suitable for maximum use temperature up to 1000 deg F. Comply with ASTM C1393.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville; a Berkshire Hathaway company
 - b. Manson Insulation Inc.
 - 2. Semirigid board material with factory-applied ASJ jacket.
- 2.2 ADHESIVES
- A. Materials are compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
 - B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. VOC limit: 50 g/L.
 - C. Glass-Fiber and Mineral Wool Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. VOC limit: 10 g/L.
 - 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. VOC limit: 50 g/L.

2.3 MASTICS AND COATINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Childers Products / H.B. Fuller Construction Products
 - 2. Foster Products / H.B. Fuller Construction Products
 - 3. Vimasco Corporation
 - 4. Mon-Eco Industries
- B. Materials are compatible with insulation materials, jackets, and substrates.
- C. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 2. VOC limit: 50 g/L.
 - 3. Comply with MIL-PRF-19565C, Type II, for permeance requirements.
- D. Vapor-Retarder Mastic, Solvent Based, Exterior Use: Suitable for outdoor use on below ambient services.
 - 1. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 2. VOC limit: 50 g/L.
- E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM E96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.

2.4 DUCT LAGGING

- A. Adhesives description: Comply with MIL-A-3316C, Class I, Grade A and are compatible with insulation materials, jackets, and substrates.
 - 1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
 - 2. Service Temperature Range: 0 to plus 180 deg F.
- B. Duct Lagging, Reinforced Foil-Faced Vinyl Barrier Bonded to 1" Scrim Faced, equal to IES2000 model 1B QA-3.
 - 1. 1" nominal thickness.
 - 2. "R" Factor: 4
 - 3. Flammability – Class A per ASTM E84.

2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 - 1. Materials are compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F.

4. VOC limit: 40 g/L.

B. ASJ Flashing Sealants, and PVC Jacket Flashing Sealants:

1. Materials are compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. VOC limit: 40 g/L.

2.6 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.
2. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C1136, Type I.
3. ASJ+: All Service Jacket composed of aluminum foil reinforced with glass scrim bonded to a kraft paper interleaving with an outer film leaving no paper exposed; complying with ASTM C 1136 Type I, II, III, IV, VII, VIII, and X.
4. ASJ+-SSL: ASJ+ jacket with Self-Sealing Advanced Closure System; complying with ASTM C 1136 Type I, II, III, IV, VII, VIII, and X secured with self-sealing longitudinal laps and matching ASJ+ butt wraps.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets comply with ASTM C921, Type I, unless otherwise indicated.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136.

1. Width: 3 inches.
2. Thickness: 11.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.
6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

1. Width: 3 inches.
2. Thickness: 6.5 mils.
3. Adhesion: 90 ounces force/inch in width.
4. Elongation: 2 percent.
5. Tensile Strength: 40 lbf/inch in width.

6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 1. Width: 2 inches.
 2. Thickness: 3.7 mils.
 3. Adhesion: 100 ounces force/inch in width.
 4. Elongation: 5 percent.
 5. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

- A. Bands:
 1. Stainless Steel: ASTM A167 or ASTM A240/A240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
 2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
 3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

PART 3 - EXECUTION

3.1 DUCTWORK INSULATION

- A. Omit insulation on the following:
 1. Fibrous-glass ducts.
 2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
 3. Factory-insulated flexible ducts.
 4. Factory-insulated plenums and casings.
 5. Flexible connectors.
 6. Vibration-control devices.
 7. Factory-insulated access panels and doors.
 8. Outdoor air ductwork supplying room neutral air.
- B. Interior Ductwork:
 1. Insulate the following duct systems:
 - a. Supply Air from Water Source Heat Pumps.
 - b. Return Air:
 - 1) Omit insulation on return ductwork located in return air ceiling plenums except all return air ductwork within 10 feet of exterior roof or wall penetrations or as noted on plans.
 - c. Exhaust and Relief Air:
 - 1) Within 10 feet of exterior discharge outlet.

- 2) Downstream of heat recovery device (wheel, plate, heat pipe, etc.) to exterior discharge outlet.
 - d. HVAC plenums and unit housings not pre-insulated at factory or lined.
 - e. Range hood non-grease exhaust ductwork within 10 feet of roof penetration.
- 2. Insulate each ductwork system specified above with one of the following types and thickness of insulation:
 - a. Duct Wrap: 2" thick, minimum R-6.
 - b. Rigid Fiberglass: 2" thick, minimum R-6.
 - c. Flexible Elastomeric: 2" thick, minimum R-6.
- C. Exterior Ductwork:
 - 1. Insulate the following exterior ductwork:
 - a. Outside air intake from louver to conditioning unit.
 - b. Exhaust air from louver to conditioning unit.
 - 2. Insulate each ductwork system specified above with one of the following types and thickness of insulation:
 - a. Duct Wrap: 2" thick, minimum R-8.
 - b. Rigid Fiberglass: 2" thick, minimum R-8.
 - c. Flexible Elastomeric: 2" thick, minimum R-8.

3.2 PIPING INSULATION

- A. Omit insulation on the following:
 - 1. Hot piping within radiation enclosures or unit cabinets;
 - 2. Cold piping within unit cabinets provided piping is located over drain pan;
 - 3. Heating piping between coil and shutoff valves provided piping is located within heated space and not more than three feet from coil;
 - 4. Flexible connections and expansion joints in pipes with fluids above ambient temperatures.
 - 5. Water Hammer Arrestors
 - 6. Balancing and flow valves
 - 7. Drain lines from condensing boilers.
- B. Insulate the following piping systems with one of the following types and thickness of insulation:
 - 1. Ground Source Heat pump water inside the building.
 - a. Flexible Elastomeric: 1" thick.
 - b. Glass Fiber, Preformed Pipe Insulation, Type I: 1" thick
 - 2. Water lines to Evaporative Fluid coolers outside the building.
 - a. Flexible Elastomeric: 1" thick.
 - 3. Refrigerant Suction and Liquid

- a. Refer to manufacturers pipe operating temperatures and applicable energy code requirements.

3.3 EQUIPMENT INSULATION

- A. Omit insulation on the following:
 - 1. Pre-Insulated equipment.
- B. Ground Source Heat Pump Water Equipment
 - 1. Insulate the following equipment unless pre-insulated at factory:
 - a. GSHP water expansion tanks, air separators and piping accessories.
 - 2. Insulate each item of equipment specified above with one of the following types and thicknesses of insulation:
 - a. Fiberglass: 1" thick.
 - b. Flexible Elastomeric: 1" thick.

3.4 JACKETS

- A. Provide jackets on insulation for the following systems:
 - 1. Interior supply and outside air ductwork
 - a. Provide FSK jackets.
 - 2. Interior piping
 - a. Provide ASJ, ASJ+, or ASJ+-SSL jackets.
 - 3. Exterior piping:
 - a. Flexible Elastomeric Pipe Insulation Exposed to Weather: Protect elastomeric piping insulation using one of the following:
 - 1) After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
 - 2) Provide multi-ply, polymeric blend laminate jacketing, 16 mils thick with approved adhesive. Provide insulation shields so that the piping supports do not puncture, cut or break the jacket. Seal all vertical joints with tape.

3.5 DUCTWORK INSULATION INSTALLATION REQUIREMENTS

- A. To ensure that it will achieve its highest possible performance and serve its intended purpose, install Duct Liner insulation and all accessories in accordance with manufacturer's published instructions (latest edition) and industry practices detailed by the NAIMA FGDLS (North American Insulation Manufacturers Association; Fibrous Glass Duct Liner Standard) or SMACNA HVAC DCS (Sheet Metal and Air Conditioning Contractors' National Association; HVAC Duct Construction Standards – Metal & Flexible).
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- C. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.

- E. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- F. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- G. Install multiple layers of insulation with longitudinal and end seams staggered.
- H. Keep insulation materials dry during application and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with Contract Documents.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- N. Cut insulation in a manner to avoid compressing insulation.
- O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

- Q. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed. At interface of lined and wrapped ductwork, overlap lined ductwork by 2 feet (minimum) with wrapped insulation.
- R. Corner Angles: Except for oven and hood exhaust duct insulation, install corner angles on external corners of insulation on ductwork in exposed finished spaces before covering with jacketing.

3.6 PIPING INSULATION INSTALLATION REQUIREMENTS

- A. To ensure that it will achieve its highest possible performance and serve its intended purpose, install all mechanical insulation materials and accessories in accordance with manufacturer's published instructions (latest edition) and industry practices detailed by the North American Commercial and Industrial Insulation Standards Manual (latest edition). Published by Midwest Insulation.
- B. Requirements in this article generally apply to all insulation materials, except where more specific requirements are specified in various pipe insulation material installation articles below.
- C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
- D. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.
- E. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.
- F. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
 - 5. Provide vapor dam every 12 feet of straight run of pipe. Install vapor dams by the following method:
 - a. Seal the ends of pipe insulation section with vapor retarder mastic. Extend the mastic onto the pipe and up and onto the insulation jacket. Ensure the insulation butts up closely to the joint with the vapor dam and seal the butt joint with butt strip tape.
- G. Insulation Installation on Fittings, Valves, Strainers, Flanges, Mechanical Couplings, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, mechanical couplings, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.

- H. 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.

3.7 EQUIPMENT INSULATION INSTALLATION REQUIREMENTS

- A. To ensure that it will achieve its highest possible performance and serve its intended purpose, install all mechanical insulation materials and accessories in accordance with manufacturer's published instructions (latest edition) and industry practices detailed by the North American Commercial and Industrial Insulation Standards Manual (latest edition). Published by Midwest Insulation.
- B. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.
- C. Install insulation materials, forms, vapor barriers or retarders, and jackets, of thicknesses required for each item of equipment, as specified in insulation system schedules.
- D. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, compress, or otherwise damage insulation or jacket.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Keep insulation materials dry during storage, application, and finishing. Replace insulation materials that get wet during storage or in the installation process before being properly covered and sealed in accordance with the Contract Documents.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends attached to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth, but not to the extent of creating wrinkles or areas of compression in the insulation.

2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward-clinching staples along both edges of strip, spaced 4 inches o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward-clinching staples along edge at 2 inches o.c.
 4. For below-ambient services, apply vapor-barrier mastic over staples.
 5. Cover joints and seams with tape, in accordance with insulation material manufacturer's written instructions, to maintain vapor seal.
 6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.
- M. Cut insulation in a manner to avoid compressing insulation.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches in similar fashion to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Manholes.
 5. Handholes.
 6. Cleanouts.

3.8 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
- E. Insulation Installation at Floor Penetrations:
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.
- 3.9 PROTECTION AND REPLACEMENT
- A. Provide all required protection for insulation (installed and uninstalled) throughout the duration of construction to avoid exposure to moisture, deterioration, and physical damage.
- B. Replace damaged insulation which cannot be repaired satisfactorily, including insulation with vapor barrier damage and insulation that has been exposed to moisture during shipping, storage, or installation.

END OF SECTION 230700

SECTION 230923 - DIRECT DIGITAL CONTROL (DDC) 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. Section Includes:
 - 1. DDC system for monitoring and controlling of HVAC systems.
 - 2. Delivery of selected control devices to equipment and systems manufacturers for factory installation and to HVAC systems installers for field installation.

1.3 DEFINITIONS

- A. BACnet Specific Definitions:
 - 1. BACnet: Building Automation Control Network Protocol, ASHRAE 135. A communications protocol allowing devices to communicate data over and services over a network.
 - 2. BACnet Testing Laboratories (BTL): Organization responsible for testing products for compliance with ASHRAE 135, operated under direction of BACnet International.
- B. Control System Integrator: An entity that assists in expansion of existing enterprise system and support of additional operator interfaces to I/O being added to existing enterprise system.
- C. DDC System Provider: Authorized representative of, and trained by, DDC system manufacturer and responsible for execution of DDC system Work indicated.
- D. Gateway: Bidirectional protocol translator that connects control systems that use different communication protocols.
- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 SUBMITTALS

- A. Product Data: For each type of product include the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Installation, operation and maintenance instructions including factors effecting performance.
 - 3. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
- B. Shop Drawings:
 - 1. General Requirements:
 - a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
 - 2. Floor Plan Drawings indicating the following:

- a. Screened backgrounds of walls, HVAC equipment, controllers, controls panels, control devices and system sensors.
 - b. Network communication cable and raceway routing.
 - c. Proposed routing of wiring, cabling, conduit, and tubing, coordinated with building services for review before installation.
 - d. Connection to location to existing campus controls system.
- 3. Schematic drawings for each controlled HVAC system indicating the following:
 - a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
 - b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
 - c. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays, and interface to DDC controllers.
 - d. Narrative sequence of operation.
 - e. DDC system network riser diagram including the interconnection of each different network in DDC system.
- C. System Description:
 - 1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
 - 2. Complete listing and description of each report, log and trend for format and timing, and events which initiate generation.
 - 3. Description of Owner training.
- D. Operation and Maintenance Data: For DDC system to include in emergency, operation, and maintenance manuals.
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - c. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - d. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - e. Licenses, guarantees, and warranty documents.
 - f. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
 - g. Owner training materials.

1.5 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace products that fail in materials or workmanship within specified warranty period.
 - 1. Failures shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Owner.
 - 2. Include updates or upgrades to software and firmware if necessary to resolve deficiencies.
 - a. Install updates only after receiving Owner's written authorization.
 - 3. Warranty service shall occur during normal business hours and commence within 24 hours of Owner's warranty service request.
 - 4. Warranty Period: 1 year(s) from date of Substantial Completion.
 - a. Warranty coverage: Full parts and Labor

PART 2 - PRODUCTS

2.1 DDC SYSTEM MANUFACTURERS

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Automated Systems Control

2.2 DDC SYSTEM DESCRIPTION

- A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.
- 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. The BAS system shall include all necessary hardware and software components to achieve the system controls functions as included in the Construction Drawings and Specifications.

2.3 WEB ACCESS

- A. DDC system shall be web based.
 - 1. Web-Based Access to DDC System:
 - a. DDC system software shall be based on server thin-client architecture, designed around open standards of web technology. DDC system server shall be accessed using a web browser over DDC system network, using Owner's LAN, and remotely over Internet.
- B. DDC System Data Storage:
 - 1. Provide data storage equivalent to what is currently provided for the existing campus.
- C. Future Expandability:
 - 1. DDC system size shall be expandable to an ultimate capacity of at least three times total I/O points indicated.

2. Additional DDC controllers, I/O and associated wiring shall be all that is needed to achieve ultimate capacity. Initial network infrastructure shall be designed and installed to support ultimate capacity.
3. Operator interfaces installed initially shall not require hardware and software additions and revisions for ultimate capacity.

D. Environmental Conditions for Controllers, Gateways, and Routers:

1. Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location.
 - a. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application.

E. Environmental Conditions for Instruments and Actuators:

1. Instruments and actuators shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.

2.4 SYSTEM ARCHITECTURE

A. System architecture shall consist of no more than two levels of LANs.

1. Level one LAN shall connect network controllers and operator workstations.
2. Level two LAN shall connect programmable application controllers to other programmable application controllers, and to network controllers.

2.5 DDC SYSTEM OPERATOR INTERFACES

A. Operator Means of System Access: Operator shall be able to access entire DDC system through any of multiple means, including, but not limited to, the following:

1. Portable operator workstation with wireless connection through LAN router.
2. Mobile device and application with secured wireless connection through LAN router or cellular data service.
3. Remote connection through web access.

B. Critical Alarm Reporting:

1. Operator-selected critical alarms shall be sent by DDC system to notify operator of critical alarms that require immediate attention.
2. DDC system shall send alarm notification to multiple recipients that are assigned for each alarm.
3. DDC system shall notify recipients by any or all means, including e-mail, text message and prerecorded phone message to mobile and landline phone numbers.

C. ASHRAE 135 Protocol:

1. ASHRAE 135 communication protocol shall be sole and native protocol used throughout entire DDC system.

2. DDC system shall not require use of gateways except to integrate HVAC equipment and other building systems and equipment, not required to use ASHRAE 135 communication protocol.
3. If used, gateways shall connect to DDC system using ASHRAE 135 communication protocol and Project object properties and read/write services indicated by interoperability schedule.
4. Operator workstations, controllers and other network devices shall be tested and listed by BACnet Testing Laboratories.

2.6 DDC SYSTEM WIRELESS NETWORKS

- A. Use Zigbee or an open industry standard and technology used by multiple DDC system manufacturers technology to create a wireless mesh network to provide wireless connectivity for network devices at multiple system levels including communications from programmable application controllers and application-specific controllers to temperature sensors and from network controllers to programmable application controllers and application-specific controllers.
- B. Installer shall design wireless networks to comply with DDC system performance requirements indicated. Wireless network devices shall co-exist on same network with hardwired devices.
- C. Hardwired controllers shall be capable of retrofit to wireless devices with no special software.

2.7 WORKSTATIONS

- A. Coordinate workstation requirements including type(s), performance, and installed location with Owner.

2.8 SYSTEM SOFTWARE

- A. System Software Minimum Requirements:
 1. Real-time multitasking and multiuser 64-bit operating system that allows concurrent multiple operator workstations operating and concurrent execution of multiple real-time programs and custom program development.
 2. Scheduling software shall schedule centrally based time and event, temporary, and exception day programs.
- B. Operator Interface Software:
 1. Security Access:
 - a. Operator access to DDC system shall be under password control.
 - b. Each operator shall be assigned an access level to restrict access to data and functions the operator is cable of performing.
- C. Graphic Interface Software:
 1. Include a full interactive graphical selection means of accessing and displaying system data to operator. Include at least five levels with the penetration path operator assignable (for example, site, building, floor, air-handling unit, and supply temperature loop). Native language descriptors assigned to menu items are to be operator defined and modifiable under password control.
 2. Include a hierarchical-linked dynamic graphic operator interface for accessing and displaying system data and commanding and modifying equipment operation. Interface shall use a pointing device with pull-down or penetrating menus, color and animation to facilitate operator understanding of system.

3. Display operator accessed data on the monitor.
 4. Dynamic data shall be assignable to graphics.
 5. Display points (physical and software) with dynamic data provided by DDC system with appropriate text descriptors, status or value, and engineering unit.
 6. Use color, rotation, or other highly visible means, to denote status and alarm states. Color shall be variable for each class of points, as chosen by operator.
 7. For operators with appropriate privilege, points shall be commanded directly from display using pointing device.
 - a. For an analog command point such as set point, current conditions and limits shall be displayed and operator can position new set point using pointing device.
 - b. For a digital command point such as valve position, valve shall show its current state such as open or closed and operator could select alternative position using pointing device.
 8. Graphic generation software shall allow operator to add, modify, or delete system graphic displays.
 - a. Include libraries of symbols depicting HVAC symbols such as fans, coils, filters, dampers, valves pumps, and electrical symbols
- D. Project-Specific Graphics: Graphics documentation including, but not limited to, the following:
1. Site plan showing each building, and additional site elements, which are being controlled or monitored by DDC system.
 2. Plan for each building floor, including interstitial floors, and each roof level of each building, showing the following:
 - a. Room layouts with room identification and name.
 - b. Locations and identification of all monitored and controlled HVAC equipment and other equipment being monitored and controlled by DDC system.
 - c. Location and identification of each hardware point being controlled or monitored by DDC system.
 3. Graphic display for each piece of equipment connected to DDC system through a data communications link. Include dynamic indication of all points associated with equipment.
 4. DDC system network riser diagram that shows schematic layout for entire system including all networks and all controllers, gateways operator workstations and other network devices.
- E. Alarm Handling Software:
1. Include alarm handling software to report all alarm conditions monitored and transmitted through DDC controllers, gateways and other network devices.
 2. Include first in, first out handling of alarms according to alarm priority ranking, with most critical alarms first, and with buffer storage in case of simultaneous and multiple alarms.
 3. Alarm handling shall be active at all times to ensure that alarms are processed even if an operator is not currently signed on to DDC system.
 4. Alarms display shall include the following:

- a. Indication of alarm condition such as "Abnormal Off," "Hi Alarm," and "Low Alarm."
 - b. "Analog Value" or "Status" group and point identification with native language point descriptor such as "Space Temperature, Building 110, 2nd Floor, Room 212."
 5. Alarms shall be directed to appropriate operator workstations, printers, and individual operators by privilege level and segregation assignments.
 6. Send e-mail alarm messages to designated operators.
 7. Send e-mail, page, text and voice messages to designated operators for critical alarms.
 - F. Reports and Logs:
 1. Include reporting software package that allows operator to select, modify, or create reports using DDC system I/O point data available.
 2. Each report shall be definable as to data content, format, interval and date.
 3. Operator shall be able to obtain real-time logs of all I/O points by type or status, such as alarm, point lockout, or normal.
 4. Reports and logs shall be stored on server hard drives in a format that is readily accessible by other standard software applications, including spreadsheets and word processing.
 5. Reports and logs shall be readily printed and set to be printed either on operator command or at a specific time each day.
 - G. Standard Reports: Standard DDC system reports shall be provided and operator shall be able to customize reports later.
 1. All I/O: With current status and values.
 2. Alarm: All current alarms, except those in alarm lockout.
 3. Disabled I/O: All I/O points that are disabled.
 4. Alarm Lockout I/O: All I/O points in alarm lockout, whether manual or automatic.
 5. Alarm Lockout I/O in Alarm: All I/O in alarm lockout that are currently in alarm.
 6. Logs:
 - a. Alarm history.
 - b. System messages.
 - c. System events.
 - d. Trends.
 - H. Custom Reports: Operator shall be able to easily define any system data into a daily, weekly, monthly, or annual report. Reports shall be time and date stamped and shall contain a report title.
- 2.9 DDC CONTROLLERS
- A. DDC system shall consist of a combination of network controllers, programmable application controllers and application-specific controllers to satisfy performance requirements indicated.
 - B. DDC controllers shall perform monitoring, control, energy optimization and other requirements indicated.

- C. Each DDC controller shall be capable of full and complete operation as a completely independent unit and as a part of a DDC system wide distributed network.
- D. Environment Requirements:
 - 1. Controller hardware shall be suitable for the anticipated ambient conditions.
- E. Input and Output Point Interface:
 - 1. Hardwired input and output points shall connect to network, programmable application and application-specific controllers.
 - 2. Input and output points shall be protected so shorting of point to itself, to another point, or to ground will not damage controller.
 - 3. Input and output points shall be protected from voltage up to 24 V of any duration so that contact will not damage controller.
 - 4. AIs:
 - a. AIs shall include monitoring of low-voltage (zero- to 10-V dc), current (4 to 20 mA) and resistance signals from thermistor and RTD sensors.
 - b. AIs shall be compatible with, and field configurable to, sensor and transmitters installed.
 - c. Controller AIs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
 - d. Signal conditioning including transient rejection shall be provided for each AI.
 - e. Capable of being individually calibrated for zero and span.
 - f. Incorporate common-mode noise rejection of at least 50 dB from zero to 100 Hz for differential inputs, and normal-mode noise rejection of at least 20 dB at 60 Hz from a source impedance of 10000 ohms.
 - 5. AOs:
 - a. Controller AOs shall perform analog-to-digital (A-to-D) conversion with a minimum resolution of 12 bits or better to comply with accuracy requirements indicated.
 - b. Output signals shall have a range of 4 to 20 mA dc or zero- to 10-V dc as required to include proper control of output device.
 - c. Capable of being individually calibrated for zero and span.
 - d. AOs shall not exhibit a drift of greater than 0.4 percent of range per year.
 - 6. BIs:
 - a. Controller BIs shall accept contact closures and shall ignore transients of less than 5-ms duration.
 - b. Isolation and protection against an applied steady-state voltage of up to 180-V ac peak.
 - c. BIs shall include a wetting current of at least 12 mA to be compatible with commonly available control devices and shall be protected against effects of contact bounce and noise.

- d. BIs shall sense "dry contact" closure without external power (other than that provided by the controller) being applied.
 - e. Pulse accumulation input points shall comply with all requirements of BIs and accept up to 10 pulses per second for pulse accumulation. Buffer shall be provided to totalize pulses. Pulse accumulator shall accept rates of at least 20 pulses per second. The totalized value shall be reset to zero on operator's command.
7. BOs:
- a. Controller BOs shall include relay contact closures or triac outputs for momentary and maintained operation of output devices.
 - 1) Relay contact closures shall have a minimum duration of 0.1 second. Relays shall include at least 180 V of isolation. Electromagnetic interference suppression shall be provided on all output lines to limit transients to non-damaging levels. Minimum contact rating shall be 1 A at 24-V ac.
 - 2) Triac outputs shall include at least 180 V of isolation. Minimum contact rating shall be 1 A at 24-V ac.
 - b. BOs shall include for two-state operation or a pulsed low-voltage signal for pulse-width modulation control.
 - c. BOs shall be selectable for either normally open or normally closed operation.
 - d. Include tristate outputs (two coordinated BOs) for control of three-point floating-type electronic actuators without feedback.
 - e. Limit use of three-point floating devices to VAV terminal unit control applications
 - f. Control algorithms shall operate actuator to one end of its stroke once every 24 hours for verification of operator tracking.

2.10 NETWORK CONTROLLERS

A. General Network Controller Requirements:

- 1. Include adequate number of controllers to achieve performance indicated.
- 2. System shall consist of one or more independent, standalone, microprocessor-based network controllers to manage global strategies indicated.
- 3. Controller shall have enough memory to support its operating system, database, and programming requirements.
- 4. Data shall be shared between networked controllers and other network devices.
- 5. Operating system of controller shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and allow for central monitoring and alarms.
- 6. Controllers that perform scheduling shall have a real-time clock.
- 7. Controller shall continually check status of its processor and memory circuits. If an abnormal operation is detected, controller shall assume a predetermined failure mode and generate an alarm notification.
- 8. Controllers shall be fully programmable.

B. Communication:

1. Network controllers shall communicate with other devices on DDC system Level one network.
2. Network controller also shall perform routing if connected to a network of programmable application and application-specific controllers.

2.11 CONTROLLER SOFTWARE

A. General Controller Software Requirements:

1. Software applications shall reside and operate in controllers. Editing of applications shall occur at operator workstations.

B. Security:

1. Operator access shall be secured using individual security passwords and user names.
2. Passwords shall restrict operator to points, applications, and system functions as assigned by system manager.

C. Scheduling: Include capability to schedule each point or group of points in system. Each schedule shall consist of the following:

1. Weekly Schedule:

- a. Include separate schedules for each day of week.
- b. Each schedule should include the capability for start, stop, optimal start, optimal stop, and night economizer.
- c. Each schedule may consist of up to 10 events.
- d. When a group of objects are scheduled together, include capability to adjust start and stop times for each member.

2. Exception Schedules:

- a. Include ability for operator to designate any day of the year as an exception schedule.
- b. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed, it will be discarded and replaced by regular schedule for that day of week.

3. Holiday Schedules:

- a. Schedules may be placed on scheduling calendar and will be repeated each year.
- b. Operator shall be able to define length of each holiday period.

D. System Coordination:

1. Include standard application for proper coordination of equipment.
2. Application shall include operator with a method of grouping together equipment based on function and location.
3. Group may then be used for scheduling and other applications.

E. Binary Alarms:

1. Each binary point shall be set to alarm based on operator-specified state.
2. Include capability to automatically and manually disable alarming.

F. Analog Alarms:

1. Each analog object shall have both high and low alarm limits.
 2. Alarming shall be able to be automatically and manually disabled.
 - G. Alarm Reporting:
 1. Operator shall be able to determine action to be taken in event of an alarm.
 2. Alarms shall be routed to appropriate operator workstations based on time and other conditions.
 3. Alarm shall be able to start programs, print, be logged in event log, generate custom messages, and display graphics.
 - H. Remote Communication:
 1. System shall have ability to dial out in the event of an alarm.
 - I. Maintenance Management: System shall monitor equipment status and generate maintenance messages based on operator-designated run-time, starts, and calendar date limits.
 - J. Control Loops:
 1. Support any of the following control loops, as applicable to control required:
 - a. Two-position (on/off, open/close, slow/fast) control.
 - b. Proportional plus integral plus derivative (PID) control.
 - 1) Include PID algorithms with direct or reverse action and anti-windup.
 - 2) Algorithm shall calculate a time-varying analog value used to position an output or stage a series of outputs.
 - 3) Controlled variable, set point, and PID gains shall be operator-selectable.
 - c. Adaptive (automatic tuning).
 - K. Anti-Short Cycling:
 1. BO points shall be protected from short cycling.
 2. Feature shall allow minimum on-time and off-time to be selected.
 - L. On and Off Control with Differential:
 1. Include an algorithm that allows a BO to be cycled based on a controlled variable and set point.
 2. Algorithm shall be direct- or reverse-acting and incorporate an adjustable differential.
- 2.12 CONTROL WIRE AND CABLE
- A. Wire: Single conductor control wiring above 24 V.
 1. Wire size shall be at least No. 16 AWG.
 2. Conductor shall be 7/24 soft annealed copper strand with 2- to 2.5-inch lay.
 3. Conductor insulation shall be 600 V, Type THWN or Type THHN, and 90 deg C according to UL 83.
 4. Conductor colors shall be black (hot), white (neutral), and green (ground).
 5. Furnish wire on spools.

- B. Single Twisted Shielded Instrumentation Cable above 24 V:
 - 1. Wire size shall be a minimum No. 20 AWG.
 - 2. Conductors shall be a twisted, 7/24 soft annealed copper strand with a 2- to 2.5-inch lay.
 - 3. Conductor insulation shall have a Type THHN/THWN or Type TFN rating.
 - 4. Shielding shall be 100 percent type, 0.35/0.5-mil aluminum/Mylar tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 - 5. Outer jacket insulation shall have a 600-V, 90-deg C rating and shall be Type TC cable.
 - 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 - 7. Furnish wire on spools.
- C. Single Twisted Shielded Instrumentation Cable 24 V and Less:
 - 1. Wire size shall be a minimum No. 20 AWG.
 - 2. Conductors shall be a twisted, 7/24 soft annealed copper stranding with a 2- to 2.5-inch lay.
 - 3. Conductor insulation shall have a nominal 15-mil thickness, constructed from flame-retardant PVC.
 - 4. Shielding shall be 100 percent type, 1.35-mil aluminum/polymer tape, helically applied with 25 percent overlap, and aluminum side in with tinned copper drain wire.
 - 5. Outer jacket insulation shall have a 300-V, 105-deg C rating and shall be Type PLTC cable.
 - 6. For twisted pair, conductor colors shall be black and white. For twisted triad, conductor colors shall be black, red and white.
 - 7. Furnish wire on spools.
- D. LAN and Communication Cable: Comply with DDC system manufacturer requirements for network being installed.
 - 1. Cable shall be balanced twisted pair.
 - 2. Comply with the following requirements:
 - a. Cable shall be plenum rated.
 - b. Cable shall have a unique color that is different from other cables used on Project.

2.13 IDENTIFICATION

- A. Match existing campus standards. Where existing standards aren't specified, provide identification as follows:
 - 1. Self-adhesive label bearing unique identification.
 - a. Include instruments with unique identification identified by equipment being controlled or monitored, followed by point identification.
 - 2. Legend shall consist of white lettering on black background.
 - 3. Laminated acrylic or melamine plastic sign shall be engraved phenolic consisting of three layers of rigid laminate. Top and bottom layers are color-coded black with contrasting

white center exposed by engraving through outer layer and shall be fastened with drive pins.

4. Instruments, control devices, and actuators with Project-specific identification tags having unique identification numbers following requirements indicated and provided by original manufacturer do not require additional identification.

B. Raceway and Boxes:

1. Paint cover plates on junction boxes and conduit same color as the tape banding for conduits. After painting, label cover plate "HVAC Controls," using an engraved phenolic tag.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 1. Verify compatibility with and suitability of substrates.
- B. Examine roughing-in for products to verify actual locations of connections before installation.
 1. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
 2. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 DDC SYSTEM INTERFACE WITH OTHER SYSTEMS AND EQUIPMENT

- A. Communication Interface to Equipment with Integral Controls:
 1. DDC system shall have communication interface with equipment having integral controls and having a communication interface for remote monitoring or control.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install products to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Fabricate openings and install sleeves in ceilings, floors, roof, and walls required by installation of products. Before proceeding with drilling, punching, and cutting, check for concealed work to avoid damage. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. If product locations are not indicated, install products in locations that are accessible and that will permit service and maintenance from floor, equipment platforms, or catwalks without removal of permanently installed furniture and equipment.

3.4 CONTROLLER INSTALLATION

- A. Install controllers in enclosures to comply with indicated requirements.
- B. Connect controllers to field power supply. Coordinate all requirements with electrical contractor.
- C. Test and adjust controllers to verify operation of connected I/O to achieve performance indicated requirements while executing sequences of operation.
- D. Installation of Network Controllers:

1. Quantity and location of network controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

E. Installation of Programmable Application Controllers:

1. Quantity and location of programmable application controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. Install controllers in a protected location that is easily accessible by operators.
3. Top of controller shall be within 72 inches of finished floor.

F. Application-Specific Controllers:

1. Quantity and location of application-specific controllers shall be determined by DDC system manufacturer to satisfy requirements indicated.
2. For controllers not mounted directly on equipment being controlled, install controllers in a protected location that is easily accessible by operators.

3.5 ELECTRIC POWER CONNECTIONS

- A. Connect electrical power to DDC system products requiring electrical power connections.
- B. Design of electrical power to products not indicated with electric power is delegated to DDC system provider and installing trade. Work shall comply with NFPA 70 and other requirements indicated.

3.6 NETWORK INSTALLATION

- A. Install balanced twisted pair or optical fiber cable when connecting between the following network devices located in same building:
 1. Operator workstations.
 2. Operator workstations and network controllers.
 3. Network controllers.
- B. Install balanced twisted pair or copper cable (as required by equipment) when connecting between the following:
 1. Gateways.
 2. Gateways and network controllers or programmable application controllers.
 3. Routers.
 4. Routers and network controllers or programmable application controllers.
 5. Network controllers and programmable application controllers.
 6. Programmable application controllers.
 7. Programmable application controllers and application-specific controllers.
 8. Application-specific controllers.

3.7 NETWORK NAMING AND NUMBERING

- A. Naming and number convention shall be match the existing campus BAS.

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Testing:
 - 1. Final Testing: Perform final test of installed system to demonstrate acceptability as installed. Testing shall be performed according to a test plan supplied by DDC system manufacturer. Defective Work or material shall be corrected and retested. As a minimum, final testing for cable system, including spare cable, shall verify conformance of attenuation, length, and bandwidth parameters with performance indicated.

3.9 DDC SYSTEM I/O CHECKOUT PROCEDURES

- A. Check installed products before continuity tests, leak tests and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material and support.
- E. Control Damper Checkout:
 - 1. Verify that control dampers are installed correctly for flow direction.
 - 2. Verify that proper blade alignment, either parallel or opposed, has been provided.
 - 3. Verify that damper frame attachment is properly secured and sealed.
 - 4. Verify that damper actuator and linkage attachment is secure.
 - 5. Verify that actuator wiring is complete, enclosed and connected to correct power source.
 - 6. Verify that damper blade travel is unobstructed.
- F. Instrument Checkout:
 - 1. Verify that instrument is correctly installed for location, orientation, direction and operating clearances.
 - 2. Verify that attachment is properly secured and sealed.
 - 3. Verify that conduit connections are properly secured and sealed.
 - 4. Verify that wiring is properly labeled with unique identification, correct type and size and is securely attached to proper terminals.
 - 5. Inspect instrument tag against approved submittal.
 - 6. For instruments with tubing connections, verify that tubing attachment is secure and isolation valves have been provided.
 - 7. For temperature instruments:
 - a. Verify sensing element type and proper material.
 - b. Verify length and insertion.

3.10 DDC SYSTEM I/O ADJUSTMENT, CALIBRATION AND TESTING:

- A. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
- B. Equipment and procedures used for calibration shall comply with instrument manufacturer's written instructions.
- C. Control Dampers:
 - 1. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed and back to 100 percent open.
 - 2. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed and 100 percent open at proper air pressure.
 - 3. Check and document open and close cycle times for applications with a cycle time less than 30 seconds.
 - 4. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.
- D. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Switches: Calibrate switches to make or break contact at set points indicated.
- F. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
 - 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistant source.

3.11 DDC CONTROLLER I/O CONTROL LOOP TESTS

- A. Testing:
 - 1. Test every I/O point connected to DDC controller to verify that safety and operating control set points are as indicated and as required to operate controlled system safely and at optimum performance.
 - 2. Test every I/O point throughout its full operating range.
 - 3. Test every control loop to verify operation is stable and accurate.
 - 4. Adjust control loop proportional, integral and derivative settings to achieve optimum performance while complying with performance requirements indicated. Document testing of each control loop's precision and stability via trend logs.
 - 5. Test and adjust every control loop for proper operation according to sequence of operation.
 - 6. Test software and hardware interlocks for proper operation. Correct deficiencies.

3.12 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.13 DEMONSTRATION

- A. Engage a factory-authorized service representative with complete knowledge of Project-specific system installed to train Owner's maintenance personnel to adjust, operate, and maintain DDC system.
- B. Extent of Training:
 - 1. Base extent of training on scope and complexity of DDC system indicated and training requirements indicated. Provide extent of training required to satisfy requirements indicated even if more than minimum training requirements are indicated.
 - 2. Inform Owner of anticipated training requirements if more than minimum training requirements are indicated.
 - 3. Minimum Training Requirements:
 - a. Provide not less than four hours of training total.
- C. Training Content for Daily Operators:
 - 1. Basic operation of system.
 - 2. Understanding operation of each system and equipment controlled by DDC system including sequences of operation, each unique control algorithm and each unique optimization routine.
 - 3. Logging on and off system.
 - 4. Accessing graphics, reports and alarms.
 - 5. Adjusting and changing set points and time schedules.
 - 6. Understanding content of operation and maintenance manuals including control drawings.
 - 7. Understanding physical location and placement of DDC controllers and I/O hardware.
 - 8. Demonstrating the following for HVAC systems and equipment controlled by DDC system:
 - a. Operation of HVAC equipment in normal-off, -on and failed conditions while observing individual equipment, dampers and valves for correct position under each condition.
 - b. Hardware interlocks and safeties function properly and DDC system performs correct sequence of operation after electrical power interruption and resumption after power is restored.
 - c. Reporting of alarm conditions for each alarm, and confirm that alarms are received at assigned locations, including operator workstations.

END OF SECTION 230923

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.

1.2 SUMMARY

- A. Section includes hydronic piping concerning the following:
 - 1. Copper tube and fittings.
 - 2. Steel pipe and fittings.
 - 3. HDPE pipe and fittings.
 - 4. Joining materials.

1.3 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Pipe and tube. Include recycled content of each material used country of origin.
 - 2. Fittings.
 - 3. Joining materials.
 - 4. Bypass chemical feeder.
- B. Ground loop contractor qualifications:
 - 1. Certification as an approved driller from IGSHPA and/or NGWA CVCLD.

1.4 WARRANTY

- A. HDPE Manufacturer's Warranty: Manufacturer agrees to repair or replace HDPE pipe and fittings that fail in materials or workmanship within 10 years from date of Substantial Completion.
 - 1. Warranty is to cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system due to defects in materials or manufacturing.
 - 2. Warranty is to be in effect only upon submission by the Contractor to the manufacturer of valid pressure/leak documentation indicating that the system was tested and passed the manufacturer's pressure/leak test.

1.5 QUALITY ASSURANCE

- A. Soldering, brazing, and welding materials shall be lead free.
- B. Solvent cements shall be GREENGUARD Gold Certified.

1.6 CONTRACTOR QUALIFICATIONS

- A. The ground loop contractor shall be certified for geothermal ground loop installations. At a minimum, the project superintendent or lead worker shall be certified according to a recognized certification program such as the International Ground Source Heat Pump Association (IGSHPA) Accredited Installer (AI) program and/or the National Ground Water Association (NGWA) Certified Vertical Closed Loop Driller (CVCLD) designation.

- B. Each fusion technician shall be thoroughly familiar with heat fusion procedures and must have had formal training at an authorized training session resulting in certification. Technicians shall hold current and correct certification for the fusion type (i.e., butt, socket, or electrofusion) and the pipe diameter range to be installed.

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. Geothermal and Condenser-Water Piping: 150 psig at 73 deg F.
 2. Makeup-Water Piping: 150 psig at 73 deg F.
 3. Blowdown-Drain Piping: 180 deg F.
 4. Air-Vent Piping: 180 deg F.
 5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B88, Type L.
- B. Annealed-Temper Copper Tube: ASTM B88, Type K.
- C. Wrought Copper Unions: ASME B16.22.
- D. Grooved, Mechanical-Joint, Copper Tube Appurtenances:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic Company.
 2. Grooved-End Copper Fittings: ASTM B75, copper tube or ASTM B584, bronze castings.
 3. Grooved-End-Tube Couplings: To fit copper-tube dimensions; rigid pattern unless otherwise indicated; gasketed fitting EPDM-rubber gasket rated for minimum 230 deg F for use with ferrous housing, and steel bolts and nuts; 300 psig minimum CWP pressure rating.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A53/A53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Wrought-Steel Fittings: ASTM A234/A234M, wall thickness to match adjoining pipe.
- C. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 1. Material Group: 1.1.
 2. End Connections: Butt welding.
 3. Facings: Raised face.
- D. Grooved Mechanical-Joint Fittings and Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Victaulic Company.
 2. Joint Fittings: ASTM A536, Grade 65-45-12 ductile iron; ASTM A47/A47M, Grade 32510 malleable iron; ASTM A53/A53M, Type F, E, or S, Grade B fabricated steel; or ASTM A106/A106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 3. Couplings: Ductile- or malleable-iron housing and EPDM or nitrile gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- E. Steel Pipe Nipples: ASTM A733, made of same materials and wall thicknesses as pipe in which they are installed.
- 2.4 HDPE PIPE AND FITTINGS
- A. High Density Polyethylene (HDPE) Pipe: ASTM D2774, with wall thickness as indicated in "Piping Applications" Article.
1. HDPE Pipe Fittings: Socket-type pipe fittings, ASTM D3350 for Schedule 80 pipe.
 - a. All HDPE U-bend assemblies shall be factory-fabricated.
 - b. certified to dezincification resistance and stress corrosion cracking resistance
 - c. Approved by the manufacturer for direct burial.
 - d. Minimum bend radius: 25x pipe diameter.
 2. Manufactured from a PE compound that has a pipe material designation code of PE4710 when evaluated in accordance with ASTM D3350 and a color and ultraviolet stabilizer code of C or E. Code E compounds shall be stabilized against deterioration from unprotected exposure to ultraviolet rays for not less than 3 years, as evidenced by meeting the test criteria specified in AWWA C901;
 3. certified to dezincification resistance and stress corrosion cracking resistance requirements of NSF/ANSI 14;
 4. Smoke and Fire Ratings:
 - a. Where indicated on the Drawings that a plenum-rated piping system is required, the pipe is to be wrapped and/or insulated with fiberglass or mineral wool pipe insulation, field installed.
 - 1) The system is to have a flame spread classification of less than 25 and smoke development rating of less than 50.
 - 2) Pipe, wrap, or insulation as a system to meet the requirements of CAN/ULC-S102.2-03, ASTM E84 or UL 2846.
 - 3) For insulation required for thermal and condensation reasons, see Section 230719 "HVAC Piping Insulation."
- 2.5 JOINING MATERIALS
- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- D. Solder Filler Metals: ASTM B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
- E. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Condenser-water piping and interior GSHP piping, aboveground, NPS 2 and smaller, shall be type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- B. Condenser-water piping and interior GSHP piping, aboveground, NPS 2-1/2 and larger, shall be Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 1. At contractor's option, grooved end piping may be used for pipes 2-1/2" and larger in the water room.
- C. Geothermal well piping, below ground, shall be HDPE pipe. Butt-fusion, socket-fusion, and saddle fusion joints and fittings for HDPE pipe and tubing shall be installed in accordance with ASTM F2620 and the instructions of the pipe or tubing and fitting manufacturer/s.
- D. Makeup-water piping, aboveground, shall be type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- E. Blowdown-Drain piping, aboveground, shall be type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- F. 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, annealed-temper copper tubing with soldered or flared joints.
- G. Safety-Valve-Inlet and -Outlet Piping for condenser and interior GSHP 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 INSTALLATION OF PIPING ABOVE GROUND

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss,

expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install 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 unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- Q. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- R. Install sleeves for piping penetrations of walls, ceilings, and floors.
- S. Install sleeve seals for piping penetrations of concrete walls and slabs.
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors.
- U. Bull-head tees are prohibited. Do not install tee fittings in such a way that the flow through the branch leg equals the sum of the flows through the two main legs.
- V. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.
- W. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity.
- X. Underground Exterior Wall Penetrations: Seal pipe penetrations through underground exterior walls with sleeves and mechanical sleeve seals.

- Y. Elevated Floor Penetrations of Waterproof Membrane, Interior Penetrations of Non-Fire Rated Walls and Concrete Slab on Grade Penetrations: Provide sleeves and seal pipes that pass through waterproof floors, non-fire rated walls, partitions and ceilings or concrete slab on grade.

3.3 INSTALLATION OF PIPING BELOW GROUND

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Before installation of pipes in the ground, test pipes according to the manufacturer's recommendations.
- C. Install piping in boreholes according to ASTM D2774 or ASTM F645.
- D. Minimum Trench Width: 12". Provide 6" of sand or gravel above and below horizontal piping.
- E. Install piping free of sags and bends.
- F. Select system components with pressure rating equal to or greater than system operating pressure.
- G. Install groups of pipes parallel to each other.
- H. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- I. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- J. Bull-head tees are prohibited. Do not install tee fittings in such a way that the flow through the branch leg equals the sum of the flows through the two main legs.
- K. Underground Exterior Wall Penetrations: Seal pipe penetrations through underground exterior walls with sleeves and mechanical sleeve seals.
- L. Clean pipe and fittings and make heat-fusion joints according to ASTM F2620, ASTM F1055 or ASTM F3373 for electrofusion fittings. Minimize the number of joints.
- M. Purge, flush, and pressure test vertical loop piping before backfilling borehole heat exchangers. See Field Quality Control in Section 3.5.
- N. Backfill material must be free of large stones or other dense hard objects which could damage the pipe when dropped into the trench or create concentrated pipe loading.

3.4 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.

- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plain-End Mechanical-Coupled Joints: Prepare, assemble, and test joints in accordance with manufacturer's written installation instructions.
- I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tools and procedure, and brazed joints.
- J. Pressure-Sealed Joints: Use manufacturer-recommended tools and procedure. Leave insertion marks on pipe after assembly.

3.5 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 bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gauges and thermometers at coil inlet and outlet connections.

3.6 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.

2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
 7. Below ground piping: Pressure tests shall be conducted in accordance with ASTM F2164 Standard Practice for Field Leak testing of Polyethylene (PE).
- C. Check expansion tanks to determine that they are not air bound and that the system is completely full of water.
- D. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Hydronic specialty valves.
 - 2. Safety Relief Valves
 - 3. Automatic Control Valves
 - 4. Pressure Reducing Valves
 - 5. Air Vents
 - 6. Air/Dirt Separators
 - 7. Expansion Tanks
 - 8. Strainers.
 - 9. Flexible Connectors.
 - 10. Triple Duty Valves
 - 11. Pump Suction Diffusers
 - 12. Bypass chemical feeder

1.2 SUBMITTALS

- A. Product Data:
 - 1. Include construction details and material descriptions for hydronic piping specialties.
 - 2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
- B. Operation and Maintenance Data: For hydronic piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 BALANCING VALVES

- A. Manufacturers Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Fluid Technology.
 - 2. Bell & Gossett; a Xylem brand.
 - 3. Nibco Inc.
 - 4. Spirax Sarco.
 - 5. Taco Comfort Solutions.
 - 6. Victaulic Company.
 - 7. Watts Water Technologies; a Watts company.

B. Bronze, Calibrated-Orifice, Balancing Valves:

1. Body: Bronze, ball or plug type with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Plug: Resin.
4. Seat: PTFE.
5. End Connections: Threaded or socket.
6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
7. Handle Style: Lever, with memory stop to retain set position.
8. CWP Rating: Minimum 125 psig.
9. Maximum Operating Temperature: 250 deg F.

C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
2. Ball: Brass or stainless steel.
3. Stem Seals: EPDM O-rings.
4. Disc: Glass and carbon-filled PTFE.
5. Seat: PTFE.
6. End Connections: Flanged or grooved.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

2.2 SAFETY RELIEF VALVES

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

1. Armstrong Fluid Technology.
2. Bell & Gossett; a Xylem brand.
3. Nibco Inc.
4. Spirax Sarco.
5. Taco Comfort Solutions.
6. Victaulic Company.
7. Watts Water Technologies; a Watts company.

B. Diaphragm-Operated Safety Valves: ASME labeled.

1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.

3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Wetted, Internal Work Parts: Brass and rubber.
7. Inlet Strainer: removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.3 AUTOMATIC CONTROL VALVES

- A. Manufacturers Subject to compliance with requirements, provide products by one of the following:
 1. Armstrong Fluid Technology.
 2. Bell & Gossett; a Xylem brand.
 3. Nibco Inc.
 4. Spirax Sarco.
 5. Taco Comfort Solutions.
 6. Victaulic Company.
 7. Watts Water Technologies; a Watts company.
- B. Automatic Flow-Control Valves:
 1. Body: Brass or ferrous metal.
 2. Flow Control Assembly, provide either of the following:
 - a. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
 - b. Elastomeric Diaphragm and Polyphenylsulfone Orifice Plate: Operating ranges within 2- to 80-psig differential pressure.
 3. Combination Assemblies: Include bronze or brass-alloy ball valve.
 4. Identification Tag: Marked with zone identification, valve number, and flow rate.
 5. Size: Same as pipe in which installed.
 6. Performance: Maintain constant flow within plus or minus 10 percent, regardless of system pressure fluctuations.
 7. Class 150.

2.4 PRESSURE REDUCING VALVES

- A. Manufacturers Subject to compliance with requirements, provide products by one of the following:
 1. Armstrong Fluid Technology.
 2. Bell & Gossett; a Xylem brand.

3. Nibco Inc.
4. Spirax Sarco.
5. Taco Comfort Solutions.
6. Victaulic Company.
7. Watts Water Technologies; a Watts company.

B. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Body: Bronze or brass.
2. Disc: Glass and carbon-filled PTFE.
3. Seat: Brass.
4. Stem Seals: EPDM O-rings.
5. Diaphragm: EPT.
6. Low inlet-pressure check valve.
7. Inlet Strainer: Removable without system shutdown.
8. Valve Seat and Stem: Noncorrosive.
9. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

2.5 AIR VENTS

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

1. American Wheatley
2. AMTROL, Inc.
3. Armstrong Fluid Technology.
4. Bell & Gossett; a Xylem brand.
5. Spirax Sarco.
6. Taco Comfort Solutions.
7. Watts Water Technologies; a Watts company.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

2.6 AIR/DIRT SEPARATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AMTROL, Inc.
 2. Armstrong Fluid Technology.
 3. Bell & Gossett; a Xylem brand.
 4. Grundfos.
 5. Taco Comfort Solutions.
- B. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig (862-kPa) working pressure and 240 deg F (130 deg C) maximum operating temperature.
- C. Coalescing Medium: Copper or Stainless steel.
- D. Air Vent: Threaded to the top of the separator.
- E. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
- F. Blowdown Connection: Threaded to the bottom of the separator.

2.7 EXPANSION TANKS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AMTROL, Inc.
 2. Armstrong Fluid Technology.
 3. Bell & Gossett; a Xylem brand.
 4. Grundfos.
 5. Taco Comfort Solutions.
 6. Watts Water Technologies; a Watts company.
- B. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. 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.
- C. Diaphragm or Bladder-Type ASME Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 2. Diaphragm or bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- D. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.8 STRAINERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong International
 2. Metraflex Company (The).
 3. Spirax Sarco
 4. Victaulic Company.
 5. Watts Water Technologies; a Watts company.
 6. Zurn Industries, LLC.
- B. Y-Pattern Strainers:
1. Body: ASTM A126, Class B, cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
 3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
 4. CWP Rating: 125 psig.
- C. Basket Strainers:
1. Body: ASTM A126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
 2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
 3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
 4. CWP Rating: 125 psig.

2.9 FLEXIBLE CONNECTORS

- A. Stainless-Steel Bellow, Flexible Connectors:
1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
 2. End Connections: Threaded or flanged to match equipment connected.
 3. Performance: Capable of 3/4-inch misalignment.
 4. CWP Rating: 150 psig.

5. Maximum Operating Temperature: 250 deg F.
 - B. Spherical, Rubber, Flexible Connectors:
 1. Body: Fiber-reinforced rubber body.
 2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 3. Performance: Capable of misalignment.
 4. CWP Rating: 150 psig.
 5. Maximum Operating Temperature: 250 deg F.
 - C. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: (Hydronic System equipment connections smaller than 4")
 1. Body: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid.
 2. End Connections: steel nipples or flanges, welded to hose.
 3. Performance: Capable of misalignment.
 4. CWP Rating: 150 psig.
 5. Maximum Operating Temperature: 250 deg F.
- 2.10 TRIPLE DUTY VALVES:
- A. Materials:
 1. Cast-iron body with bronze disc and seat, stainless steel stem and spring, and "Teflon" packing.
 - B. Valve shall be rated for:
 1. 125 psig working pressure,
 2. 300 deg F maximum operating temperature.
 - C. Features:
 1. flanged connections and straight or angle pattern as indicated.
 2. Non-slam check valve with spring-loaded weighted disc
 3. Calibrated adjustment feature to permit regulation of pump discharge flow and shutoff.
- 2.11 PUMP SUCTION DIFFUSERS
- A. Diffusers shall have cast-iron body with threaded connections for 2 inch and smaller, flanged connections for 2-1/2 inch and larger;
 - B. Diffusers shall be rated for:
 1. 175 psig working pressure,
 2. 300 deg F maximum operating temperature.
 - C. Features:
 1. Inlet vanes with length 2-1/2 times pump suction diameter or greater.
 2. Cylinder strainer with 3/16 inch diameter openings with total free area equal to or greater than 5 times cross-sectional area of pump suction, designed to withstand pressure

differential equal to pump shutoff head. Provide stainless steel strainer in condenser water systems.

3. Provide disposable fine mesh, stainless steel strainer to fit over cylinder strainer for cleaning during startup procedures.
4. Blowdown tapping in bottom; gauge tapping in side
5. Permanent magnet located in flow stream, removable for cleaning.
6. Adjustable foot support, designed to carry weight of suction piping.

2.12 BYPASS CHEMICAL FEEDER

- A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
 1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 SPECIALTY VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install throttling-duty valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 SPECIALTY EQUIPMENT INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet or air separator to expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators on pump suction side. Install drain valve on air separators NPS 2 and larger.
- E. 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.

- F. Install blowdown piping with gate valve; extend to nearest drain.
- G. Do not include strainer in suction diffusers installed with pumps serving open condenser water systems, such as cooling towers.
- H. Install water filtration system per manufacturer installation instructions. Provide support for unit as scheduled on the drawings.
- I. Install piping between water filtration system and cooling tower per water filtration system manufacturer recommendations.

3.3 CHEMICAL TREATMENT

- A. Install bypass chemical feeders in hydronic system where indicated.
 - 1. Install in upright position with top of funnel not more than 48 inches above the floor.
 - 2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
 - 3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
- B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

3.4 STARTUP

- A. Start up and commissioning of water filtration unit shall be performed by a factory authorized representative.
- B. Start up and commissioning of glycol makeup unit shall be performed by a factory authorized representative.

3.5 TRAINING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water filtration equipment and/or glycol makeup equipment.
- B. Training for Owner's personnel shall include but not be limited to:
 - 1. Overview of the system and /or equipment as it relates to the facility.
 - 2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance, and appropriate operator intervention.
 - 3. Review manufacturer's safety data sheets for handling of chemicals.
 - 4. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service. Refer to Division 1 and Division 23 Section "General Mechanical Requirements."
- C. Schedule training with Owner, through Architect, with at least seven days' advance notice.
- D. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees, and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. In-line centrifugal pumps.

1.2 SUBMITTALS

A. Product Data: For each type of pump.

1. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated.
2. Indicate pump's operating point on curves.

B. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.3 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.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.5 MAINTENANCE MATERIAL

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Mechanical Seals: One mechanical seal for each pump.

1.6 WARRANTY

A. A.Warranty on Pumps: Provide written warranty, signed by manufacturer, agreeing to replace/repair, within warranty period, pumps with inadequate or defective materials and workmanship, including leakage, breakage, improper assembly, or failure to perform as required; provided manufacturer's instructions for handling, installing, protecting, and maintaining units have been adhered to during warranty period. Replacement includes both parts and labor for removal and reinstallation.

1. Warranty Period: One year from date of substantial completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bell & Gossett, ITT.
2. Armstrong Fluid Technology.
3. Grundfos Pumps Corporation.
4. Mepco, LLC.
5. Patterson Pump Company; a Gorman-Rupp company.
6. Peerless Pump Company.
7. Taco Comfort Solutions.

2.2 IN-LINE CENTRIFUGAL PUMPS

A. Source Limitations: Obtain pumps from single source from single manufacturer. Provide packaged system with pumps, base, valves, gauges, pressure transducers, suction & discharge headers, controls and drives.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tapings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.
2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Bronze.
4. Pump Stub Shaft: Type 304 or Type 316 stainless steel.
5. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless steel spring, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.
7. Pump Bearings: Permanently lubricated ball bearings.

D. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors.

1. Enclosure : Totally enclosed, fan cooled.
2. NEMA Premium Efficient motors as defined in NEMA MG 1.
3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

5. Variable-speed motor.
6. Provide integral pump motor variable-speed controller.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4 and HI 2.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting:
 1. Install base-mounted pumps on cast-in-place concrete equipment bases.
 2. Support pump base plate on rectangular metal blocks and shims, or on metal wedges having a small taper, at points near the foundation bolts to provide a gap of 3/4 to 1-1/2 inches between the pump base and the foundation for grouting.
 3. Adjust the metal supports or wedges until the shafts of the pump and driver are level. Check the coupling faces and suction and discharge flanges of the pump to verify that they are level and plumb.
- E. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and neoprene vibration isolation hangers of size required to support weight of in-line pumps.

3.3 ALIGNMENT

- A. Perform alignment service. When required by manufacturer to maintain warranty coverage, engage a factory-authorized service representative to perform it.
- B. Comply with requirements in HI standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 PIPING CONNECTIONS

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check, shutoff, and throttling valves on discharge side of pumps.
- E. Install triple-duty valve on discharge side of end-suction pumps.
- F. Install Y-type strainer, suction diffuser, and shutoff valve on suction side of pumps.
 - 1. Use startup strainer for initial system startup. Install permanent strainer element before turnover of system to Owner.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gauges on pump suction and discharge or at integral pressure-gauge tapping, or install single gauge with multiple-input selector valve.

3.5 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- B. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.

3.6 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping. Use startup strainer for initial startup.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Hydronic pumps will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 DEMONSTRATION

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

- B. Content: Training shall include but not be limited to:
 - 1. Overview of the system and/or equipment as it relates to the facility as a whole.
 - 2. Operation and maintenance procedures and schedules related to startup and shutdown, troubleshooting, servicing, preventive maintenance and appropriate operator intervention.
 - 3. Review data included in the operation and maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
- C. Certification: Contractor shall submit to the Engineer a certification letter stating that the Owner's designated representative has been trained as specified herein. Letter shall include date, time, attendees and subject of training. The certification letter shall be signed by the Contractor and the Owner's representative indicating agreement that the training has been provided.
- D. Schedule: Schedule training with Owner with at least 7 days' advance notice.

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Copper tube and fittings.
 - 2. Valves and specialties.

1.2 SUBMITTALS

- A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
- B. Shop Drawings:
 - 1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
 - 2. Show interface and spatial relationships between piping and equipment.

1.3 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."
- C. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.
- D. Installer Qualification: Only trained installers skilled in refrigeration pipe installation and brazing of copper tubing should be used.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Conex Banninger - USA.
 - 2. Parker Hannifin, Sporlan Division.
 - 3. RLS LLC.
- B. Use one of the following copper tubes:
 - 1. ASTM B 88, Type K or L
 - 2. ASTM B 280, Type ACR.
 - 3. Bendable ACR Copper
 - a. Straight Lengths: ASTM B 75, UNS C12200, H55 Temper (Light Drawn), ACR Bending Quality; Cleaned, Eddy Current Tested, and Plugged per ASTM B 280.
 - b. Coiled: ASTM B 280, UNS C12200, O60 Temper (Soft Annealed), ACR, cleaned and capped
- C. Wrought-Copper Fittings, Solder-Joint: ASME B16.22.

- D. Wrought-Copper Fittings, Braze-Joint: ASME B16.50.
- E. Wrought-Copper Unions: ASME B16.22.
- F. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- G. Brazing Filler Metals: AWS A5.8/A5.8M.
- H. Field Swaged Brazing Cups: MSS-SP-73, ASME B 16.50
- I. Field Bends (all angles): ASME B31.5
- J. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Working Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.
- K. Copper-Tube, Pressure-Seal-Joint Fittings for Refrigerant Piping:
 - 1. Standard: UL 207; certified by UL for field installation. Certification as a UL-recognized component alone is unacceptable.
 - 2. Housing: Copper.
 - 3. O-Rings: HNBR or compatible with specific refrigerant.
 - 4. Tools: Manufacturer's approved special tools.
 - 5. Minimum Rated Pressure: 700 psig.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Above Grade:
 - 1. Type L, Type ACR, or Bendable ACR tubing.
- B. If other than Type ACR tubing is used, clean and protect inside of tubing.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valves for gauge taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- B. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- C. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- D. Provide refrigerant locking caps on refrigerant charging ports that are located outdoors unless otherwise protected from unauthorized access by a means acceptable to the authority having jurisdiction.

3.3 INSTALLATION OF PIPING, GENERAL

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- K. 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.
- L. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- M. 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.
- N. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 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.
- F. Threaded Joints: Thread steel 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 to 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. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 1. Comply with ASME B31.5, Chapter VI.
 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "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.
- B. Prepare test and inspection reports.

3.6 SYSTEM CHARGING

- A. Charge system using the following procedures:
 1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 4. Charge system with a new filter-dryer core in charging line.

3.7 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Verify that compressor oil level is correct.
 - 3. Open compressor suction and discharge valves.
 - 4. Open refrigerant valves except bypass valves that are used for other purposes.
 - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Sheet metal materials.
 - 2. Single-wall rectangular ducts and fittings.
 - 3. Single-wall round ducts and fittings.
 - 4. Duct liner.
 - 5. Sealants and gaskets.

1.2 SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Sheet metal materials. Include estimated recycled content of each material and country of origin.
 - 2. Liners and adhesives.
 - 3. Sealants and gaskets.
- B. Shop Drawings:
 - 1. Duct layout indicating sizes, configuration, liner material, static-pressure classes, and duct accessories.
 - 2. Elevation of top and bottom of ducts.
 - 3. Penetrations through fire-rated and other partitions.
 - 4. Equipment installation based on equipment being used on Project.
 - 5. Locations for access doors and panels, and required service clearances.
 - 6. Locations, types, and neck sizes for diffusers.

1.3 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:
 - 1. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for duct joint and seam welding.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A653/A653M.
 - 1. Galvanized Coating Designation: G60
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.

- C. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- D. Reinforcement Shapes and Plates: ASTM A36/A36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- E. Tie Rods: Galvanized steel, 1/4-inch-minimum diameter for lengths 36 inches or less; 3/8-inch-minimum diameter for lengths longer than 36 inches.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- B. Transverse Joints: Fabricate joints in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. For ducts with longest side less than 36 inches, select joint types in accordance with Figure 2-1.
 - 2. For ducts with longest side 36 inches or greater, use flange joint connector Type T-22, T-24, T-24A, T-25a, or T-25b. Factory-fabricated flanged duct connection system may be used if submitted and approved by engineer of record.
- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Construct ducts of galvanized sheet steel unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

- C. Longitudinal Seams: Select seam types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
- D. Tees and Laterals: Select types and fabricate in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C916.
 - 2. Black mat finish withstanding maximum rated air velocity of 6,000 ft/minute.
 - 3. When tested in accordance with ASTM C423 (Type A Mounting), shall provide a Noise Reduction Coefficient of .70 at 1.0", .80 at 1.5", and .95 at 2.0" thickness. Maximum service temperature of 250 degrees F.
 - 4. Maximum Flame spread rating of 25 and Smoke developed rating of 50 when tested in accordance with ASTM E84 or UL 723.
- B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C534/C534M, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - 1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested in accordance with UL 723; certified by an NRTL.
 - 2. Black mat finish withstanding maximum rated air velocity of 6,000 ft/minute.
 - 3. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

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 in accordance with UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 - 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal. Tape shall be a minimum 3" wide.
- C. Water-Based Joint and Seam Sealant:

1. Solids Content: Minimum 65 percent.
 2. VOC: Maximum 10 g/L (less water).
 3. Maximum Static-Pressure Class: 10 inch wg, positive and negative.
 4. Service: Indoor or outdoor.
 5. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C920.
1. General: Single-component, acid-curing, silicone, elastomeric.
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- F. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and coordination drawings.
- B. Install ducts in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Install fire and combination fire/smoke dampers where indicated on Drawings and as required by code, and by local authorities having jurisdiction. Comply with requirements in

Section 233300 "Air Duct Accessories" for fire and smoke dampers and specific installation requirements of the damper UL listing.

- K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials both before and after installation.
 - L. Elbows: Use long-radius elbows wherever they fit.
 - 1. Fabricate 90-degree rectangular mitered elbows to include turning vanes.
 - 2. Fabricate 90-degree round elbows with a minimum of three segments for 12 inches and smaller and a minimum of five segments for 14 inches and larger.
 - M. Branch Connections: Use lateral or conical branch connections.
- 3.2 ADDITIONAL INSTALLATION REQUIREMENTS FOR EXHAUST DUCTS SERVING SHOWERS AND OTHER HIGH-HUMIDITY LOCATIONS
- A. Install shower exhaust ducts and other exhaust ducts from wet, high-humidity locations without dips and traps that may hold water.
 - B. Minimize number of transverse seams.
 - C. Do not locate longitudinal seams on bottom of duct.
- 3.3 DUCT SEALING
- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article in accordance with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 3.4 PAINTING
- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.
- 3.5 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. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 3. 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.
 - 4. Test for leaks before applying external insulation.
 - 5. 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.
 - 6. Give seven days' advance notice for testing.
- 3.6 DUCT SCHEDULE
- A. Fabricate ducts as follows:

1. DUCT SCHEDULE

Duct Type	Pressure Class	Seal Class	Leakage Class	Material
Supply, Low Pressure	2	A	6	Galvanized
Return	2	A	6	Galvanized
Exhaust	2	B	6	Galvanized
Shower Exhaust	2	A	6	Aluminum
Outdoor Air	2	B	6	Aluminum

2. Shower exhaust and outdoor air may be aluminum where noted on drawings.

3. Liner (where indicated on drawings):

a. 1 inches thick.

4. Double-Wall Duct Interstitial Insulation:

a. 1 inches thick.

5. Elbow Configuration:

a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

a) Where space allows, provide elbows with a minimum 1.5 radius-to-diameter ratio.

b) Where space is limited and constrains the use of 1.5R elbows, provide 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."

b. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

1) 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.

a) Radius-to Diameter Ratio: 1.5.

2) Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.

3) Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

B. 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: high efficiency 45-degree entry.

b. Rectangular Main to Round Branch: high efficiency 45-degree entry.

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. high efficiency 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Manual volume dampers.
3. Control dampers.
4. Fire dampers.
5. Combination fire and smoke dampers.
6. Actuator for motorized dampers.
7. Flange connectors.
8. Turning vanes.
9. Remote damper operators.
10. Duct-mounted access doors.
11. Duct access panel assemblies.
12. Flexible ducts.
13. Flexible connectors.
14. Duct accessory hardware.

1.2 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of ductwork accessories, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

B. Codes and Standards:

1. SMACNA Compliance: Comply with applicable portions of SMACNA "HVAC Duct Construction Standards, Metal and Flexible", 2005 Edition.
2. ASHRAE 62.1 –2016.
3. NAIMA AH116 for fibrous-glass ducts.
4. Industry Standards: Comply with ASHRAE recommendations pertaining to construction of ductwork accessories, except as otherwise indicated.
5. The Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1.
6. UL Compliance:
 - a. Construct, test, and label fire dampers in accordance with current edition of UL Standard 555 "Fire Dampers". Construct, test, and label smoke dampers in accordance with current edition of UL Standard 555S "Smoke Dampers".
 - b. Construct flexible ductwork in compliance with UL Standard 181 "Factory-Made Air Ducts and Connections".

- c. Duct tape shall be labeled in accordance with UL Standard 181B and marked 181B-FX. Non-metallic duct clamps shall be labeled in accordance with UL Standard 181B and marked 181B-C.
 - d. Duct clamps shall be labeled in accordance with UL Standard 181B and marked 181B-C.
 - e. Grease exhaust duct wrap shall meet the fire protection requirements defined by UL Standard 1479 "Fire Tests of Through-Penetration Firestops."
 - f. Fire rated duct wrap shall meet the fire protection requirements defined by UL Standard 1479 "Fire Tests of Through-Penetration Firestops."
7. NFPA Compliance:
- a. Comply with applicable provisions of NFPA 90A "Air Conditioning and Ventilating Systems", pertaining to installation of ductwork accessories. Comply with NFPA 90B "Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
 - b. Comply with NFPA 96 "Ventilation Control and Fire Protection of Commercial Cooking Operations" for fire-rated grease exhaust ducts.
8. ASTM Compliance:
- a. Products shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 "Surface Burning Characteristics" (NFPA 255) method.
 - b. ASTM E96/E96M, "Test Methods for Water Vapor Transmission of Materials."
 - c. Duct silencers shall be tested for performance in accordance with ASTM E477 "Test Method for Measuring Acoustical and Airflow Performance of Duct Liner Materials and Prefabricated Silencers."
 - d. Grease exhaust duct wrap shall be tested for performance in accordance with ASTM E 2336 "Standard Test Methods for Fire Resistive Grease Duct Enclosure Systems" and ASTM E814 "Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops".
 - e. Fire rated duct wrap shall be tested in accordance with ASTM E814 "Standard Test Methods of Fire Resistance of Through-Penetration Fire Stops".
9. AMCA Certification: Test and rate in accordance with AMCA Publication 511.
10. Leakage:
- a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.

1.3 SUBMITTALS

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

1. For duct silencers, include pressure drop, dynamic insertion loss, and self-generated noise data. Include breakout noise calculations for high-transmission-loss casings.
 - B. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.
- 1.4 SPARE PARTS
- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Cesco Products; MESTEK, Inc.
 2. Greenheck Fan Corporation.
 3. Nailor Industries Inc.
 4. Price
 5. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 6. Titus
 7. Vent Products Co., Inc.
- B. Description: Gravity balanced.
- C. Performance:
 1. Maximum Air Velocity: 1000 fpm.
 2. Maximum System Pressure: 1 inch wg.
 3. AMCA Certification: Test and rate in accordance with AMCA 511.
 4. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
 - d. Class III: Leakage shall not exceed 40 cfm/sq. ft. against 1-inch wg differential static pressure.
- D. Construction:
 1. Frame:
 - a. Hat shaped.

- b. 16-gauge- aluminum 10-gauge- thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.
 - 2. Blade Action: Parallel.
 - E. Blade Seals:
 - 1. Round: Neoprene
 - 2. Rectangular: Extruded vinyl, or silicone.
 - F. Blade Axles:
 - 1. Material: Galvanized steel or Stainless steel.
 - 2. Diameter: 0.20 inch.
 - G. Tie Bars and Brackets: Galvanized steel.
 - H. Return Spring: Adjustable tension.
 - I. Bearings: Steel ball, Brass sleeve, or synthetic pivot bushings.
- 2.2 MANUAL VOLUME DAMPERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance; MESTEK, Inc.
 - 2. Cesco Products; MESTEK, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff.
 - 6. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - 7. Titus
 - 8. Vent Products Co., Inc.
 - B. Performance:
 - 1. Leakage Rating Class III: Leakage not exceeding 40 cfm/sq. ft. against 1-inch wg differential static pressure.
 - C. Construction:
 - 1. Linkage out of airstream.
 - 2. Suitable for horizontal or vertical airflow applications.
 - 3. Galvanized steel for normal applications, aluminum for wet or pool air, or stainless steel for corrosive air streams.
 - D. Frames:
 - 1. Hat-shaped, 16-gauge- thick, galvanized sheet steel.
 - 2. Mitered and welded corners.
 - 3. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - E. Blades:

1. Multiple or single blade.
2. Parallel- or opposed-blade design.
3. Stiffen damper blades for stability.
4. Galvanized steel; 16 gauge thick.

F. Blade Axles: Galvanized steel.

G. Bearings:

1. Dampers mounted with vertical blades to have thrust bearing at each end of every blade.
2. Tie Bars and Brackets: Galvanized steel.
3. Locking device to hold damper blades in a fixed position without vibration.

2.3 CONTROL DAMPERS

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

1. Carnes Company.
2. Cesco Products; MESTEK, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
6. Titus
7. Vent Products Co., Inc.

B. General Requirements:

1. Unless otherwise indicated, use parallel-blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed-blade configuration.
2. Factory or field assemble multiple damper sections to provide a single damper assembly of size required by the application.

C. Performance:

1. AMCA Certification: Test and rate in accordance with AMCA 511.
2. Leakage:
 - a. Class IA: Leakage shall not exceed 3 cfm/sq. ft. against 1-inch wg differential static pressure.
 - b. Class I: Leakage shall not exceed 4 cfm/sq. ft. against 1-inch wg differential static pressure.
 - c. Class II: Leakage shall not exceed 10 cfm/sq. ft. against 1-inch wg differential static pressure.
 - d. Class III: Leakage shall not exceed 40 cfm/sq. ft. against 1-inch wg differential static pressure.

3. Pressure Drop: 0.05 inch wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
4. Velocity: Up to 3000 fpm.
5. Temperature: Minus 25 to plus 180 deg F.
6. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.

D. Construction:

1. Linkage out of airstream.
2. Suitable for horizontal or vertical airflow applications.
3. Frames:
 - a. Hat, U, or angle shaped.
 - b. 16-gauge- thick, galvanized sheet steel or 18-gauge- thick stainless steel.
 - c. Mitered and welded or Interlocking, gusseted corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
4. Blades:
 - a. Multiple blade with maximum blade width of 6 inches.
 - b. Galvanized steel or Stainless steel.
 - c. 16-gauge- thick single skin.
5. Blade Edging Seals:
 - a. Replaceable Closed-cell neoprene.
6. Blade Jamb Seal: Flexible stainless steel, compression type.
7. Blade Axles: 1/2-inch diameter; galvanized or stainless steel.
8. Blade-Linkage Hardware: Zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of air stream.
9. Bearings:
 - a. Dampers mounted with vertical blades to have thrust bearings at each end of every blade.

2.4 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Air Balance; MESTEK, Inc.
 2. Cesco Products; MESTEK, Inc.
 3. Greenheck Fan Corporation.
 4. Pottorff.
 5. Prefco.
 6. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.

7. Vent Products Co., Inc.
 - B. Type: rated and labeled in accordance with UL 555 by an NRTL.
 1. Horizontal fire dampers shall be dynamic.
 2. Vertical fire dampers shall be static.
 - C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000 fpm velocity.
 - D. Fire Rating: 1-1/2 hours.
 - E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed galvanized steel; with mitered and interlocking corners; gauge in accordance with UL listing.
 - F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel or stainless steel in corrosive environments; gauge in accordance with UL listing.
 - G. Mounting Orientation: Vertical or horizontal as indicated.
 - H. Blades: Roll-formed to match casing galvanized sheet steel or stainless steel, interlocking or full-length steel blade connectors. Material gauge is to be in accordance with UL listing.
 - I. Heat-Responsive Device:
 1. Replaceable, 165 deg F rated, fusible links.
- 2.5 COMBINATION FIRE AND SMOKE DAMPERS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Air Balance; MESTEK, Inc.
 2. Cesco Products; MESTEK, Inc.
 3. Greenheck Fan Corporation.
 4. Pottorff.
 5. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 6. Safe Air - Dowco.
 - B. General Requirements:
 1. Label to indicate conformance to UL 555 and UL 555S by an NRTL.
 2. Label to indicate conformance to NFPA 80 and NFPA 90A by an NRTL.
 3. Unless otherwise indicated, use parallel-blade configuration.
 - C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 3000 fpm velocity.
 - D. Fire Rating: 1-1/2 hours.
 - E. Performance:
 1. Pressure Drop: 0.05 in. wg at 1500 fpm across a 24-by-24-inch damper when tested in accordance with AMCA 500-D, Figure 5.3.
 2. Velocity: Up to 2000 fpm.
 3. Temperature: Minus 25 to plus 180 deg F.

4. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
- F. Construction:
 1. Suitable for horizontal or vertical airflow applications.
 2. Linkage out of airstream.
 3. Frame:
 - a. Hat shaped.
 - b. Galvanized sheet steel or, stainless steel, with welded, interlocking, gusseted or mechanically attached corners and mounting flange.
 - c. Gauge is to be in accordance with UL listing.
 4. Blades:
 - a. Roll-formed, horizontal, material to match frame.
 - b. Maximum width and gauge in accordance with UL listing.
 5. Blade Edging Seals:
 - a. Silicone rubber.
 6. Blade Jamb Seal: Flexible stainless steel, compression type.
 7. Blade Axles: 1/2-inch- diameter; galvanized steel or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings. Linkage mounted out of airstream.
 8. Bearings:
 - a. Oil-impregnated bronze, oil-impregnated stainless steel sleeve, or stainless steel sleeve.
- A. Mounting Sleeve: Factory-installed, galvanized sheet steel; length to suit wall or floor application, gauge in accordance with UL listing.
- B. Heat-Responsive Device:
 1. Replaceable, 165 deg F rated, fusible links.
- C. Master control panel for use in dynamic smoke-management systems.
- 2.6 ACTUATOR FOR MOTORIZED DAMPERS:
 - A. UL 873, plenum rated.
 - B. Smoke and combination fire/smoke dampers designed to operate in smoke-control systems complying with UL 555S requirements.
 - C. Two position with fail-safe spring return.
 1. Sufficient motor torque and spring torque to drive damper fully open and fully closed with adequate force to achieve required damper seal.
 2. Maximum 15-second full-stroke closure.
 3. Minimum 90-degree drive rotation.
 - D. Clockwise or counterclockwise drive rotation as required for application.

- E. Environmental Operating Range:
 - 1. Temperature: Minus 40 to plus 130 deg F.
 - 2. Humidity: 5 to 95 percent relative humidity noncondensing.
- F. Environmental Enclosure: NEMA 2.
- G. Actuator to be factory mounted and provided with single-point wiring connection.
- H. Controllers, Electrical Devices, and Wiring:
 - 1. Electrical Connection: 115 V, single phase, 60 Hz.
- I. Accessories:
 - 1. Auxiliary switches for position indication.
 - 2. damper mounted.
 - 3. Smoke Detector: Integral, factory wired for single-point connection.

2.7 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc; a DMI company.
 - 2. Ward Industries; a brand of Hart & Cooley, LLC.
- B. Description: Add-on or roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gauge and Shape: Match connecting ductwork.

2.8 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. Ductmate Industries, Inc; a DMI company.
 - 3. Duro Dyne Inc.
 - 4. Elgen Manufacturing.
 - 5. Sheet Metal Connectors, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Fabricate curved blades of galvanized sheet steel with gauge thickness or greater than the ducts in which they are installed.; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

- E. Vane Construction:
 - 1. Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.9 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. METALAIR, Inc.
 - 2. Young Regulator Company.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Damper shall be adjustable through the diffuser face or frame with standard 1/4" nutdriver or flat screwdriver.
- D. Positive, direct, two-way damper control shall be provided with no sleeves, springs or screw adjustments to come loose after installation.
- E. Support cable assembly to avoid bends and kinks in cable.
- F. Cable: Steel.
- G. Wall-Box Mounting: Recessed.
- H. Wall-Box Cover-Plate Material: Steel.

2.10 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cesco Products; MESTEK, Inc.
 - 2. Ductmate Industries, Inc; a DMI company.
 - 3. Flexmaster U.S.A., Inc.
 - 4. Ruskin; Air Distribution Technologies, Inc.; Johnson Controls, Inc.
 - 5. Ventfabrics, Inc.
- B. Duct-Mounted Access Doors:
 - 1. Door:
 - a. Match material and gauge thickness of duct material served. Provide insulated access doors for insulated ductwork. Access door shall be recessed for ductwork without external insulation or extended for ducts with external insulation. Vision panel.
 - b. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - c. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - a. 24-gauge- thick galvanized steel or 0.032-inch- thick aluminum frame.
 - 3. Number of Hinges and Locks: Provide one side hinged, the other with 1 handle latch for doors 12" and smaller or 2 handle latches for doors greater than 12.
- C. Pressure Relief Access Door:

1. Match material and gauge thickness of duct material served. Provide insulated access doors for insulated ductwork. Access door shall be recessed for ductwork without external insulation or extended for ducts with external insulation. Vision panel.
2. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
3. Factory set at 3.0 to 8.0 inches wg.
4. Doors close when pressures are within set-point range.
5. Hinge: Continuous piano.
6. Latches: Cam.
7. Seal: Neoprene or foam rubber.
8. Insulation Fill, if surrounding ductwork is insulated: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.11 FLEXIBLE DUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Flexmaster U.S.A., Inc.
 2. McGill AirFlow LLC.
 3. Thermaflex; a Flex-Tek Group company.
- B. Non-Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.
 1. Pressure Rating: 6-inch wg positive and 1.0-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 210 deg F.
- C. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
 1. Pressure Rating: 6-inch wg positive and 1.0-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 210 deg F.
 4. Insulation R-Value: provide same as connected system.

2.12 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Ductmate Industries, Inc; a DMI company.
 2. Duro Dyne Inc.
 3. Flexmaster.
 4. Thermaflex.

- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.

2.13 DUCT ACCESSORY HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc; a DMI company.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Co.
- B. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- C. Quadrant Locks: Provide for each damper, quadrant lock device on one end of shaft; and end bearing plate on other end for damper lengths over 12". Provide extended quadrant locks and end extended bearing plates for externally insulated ductwork.
- D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. 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.
- B. Where multiple damper sections are necessary to achieve required dimensions, provide reinforcement to fully support damper assembly when fully closed at full system design static pressure.
- C. 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. Volume damper material to match duct material.
- D. Set dampers to fully open position before testing, adjusting, and balancing.
- E. Install test holes at fan inlets and outlets and elsewhere as indicated and as needed for testing and balancing.
- F. Install fire and smoke dampers in accordance with UL listing.
- G. Install access doors with swing against duct static pressure.

H. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 8 inches.
2. Two-Hand Access: 12 by 12 inches.
3. Head and Hand Access: 24 by 24 inches.
4. Head and Shoulders Access: 24 by 24 inches.
5. Body Access: 24 by 24 inches.
6. Body plus Ladder Access: 24 by 36 inches.

I. Flexible ductwork:

1. Provide insulated flexible ducts conveying supply air that is heated or cooled and return air in unconditioned spaces, including crawlspaces and ceiling plenums. Non-insulated flexible duct in all other duct systems.
2. Flexible ductwork should not be exposed to UV lighting.
3. Connect diffusers or light troffer boots to ducts with maximum 60-inch lengths of flexible duct clamped or strapped in place.
4. Connect flexible ducts to metal ducts with draw bands.
5. Installation of Flexible Ducts:
 - a. Install ducts fully extended.
 - b. Do not bend ducts across sharp corners.
 - c. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
 - d. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 - e. Install flexible ducts in a direct line, without sags, twists, or turns.
6. Supporting Flexible Ducts:
 - a. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
 - b. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
 - c. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
 - d. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

J. Install flexible connectors to connect ducts to equipment.

K. Install duct test holes where required for testing and balancing purposes.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that size and location of access doors are adequate to perform required operation.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation, and verify that vanes do not move or rattle.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233400 - HVAC FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Direct Drive Cabinet Fan.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
2. Rated capacities, operating characteristics, and furnished specialties and accessories.
3. Certified fan performance curves with system operating conditions indicated.
4. Certified fan sound-power ratings.
5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
6. Material thickness and finishes, including color charts.
7. Dampers, including housings, linkages, and operators.
8. Fan speed controllers.

B. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

1.3 MAINTENANCE MATERIAL

A. Furnish extra materials, from the same product run, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

1.4 QUALITY ASSURANCE

A. AMCA Compliance:

1. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
2. Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.
3. Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.
4. Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.

B. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

C. Manufacturer Qualifications: Provide certification that manufacturer complies with the most recent edition of ISO 9001

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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of unit components.

F. UL Compliance:

1. Listed and labeled to UL 507 – Electric Fans.
2. Listed and labeled to UL 705 – Standard Power Ventilators

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. ACME Fans.
2. Big Ass Fans.
3. Carnes Company.
4. Captive Aire.
5. ChopAir.
6. Greenheck Fan Corporation.
7. Loren Cook Company.
8. PennBarry; division of Air System Components.
9. Twin City Fan.

2.2 DIRECT DRIVE CABINET FANS

- A. Housing: Steel, lined with acoustical insulation.
- B. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel removable for service.
- C. Back-draft damper: Integral.
- D. Grille: louvered grille with flange on intake and thumbscrew or spring retainer attachment to fan housing.
- E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

2.3 MOTORS

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

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install fan according to manufacturer's published instructions.
- B. Install power ventilators level and plumb.
- C. Equipment Mounting:
 1. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
 2. Anchor fan to building structure with manufacturer's recommended mounting bracket for installed condition.

3. 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.
 4. Comply with requirements for hangers and supports
- D. Install units with clearances for service and maintenance.
- E. Label units.
- 3.2 DUCTWORK CONNECTIONS
- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors.
- 3.3 ELECTRICAL CONNECTIONS
- A. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- 3.4 CONTROL CONNECTIONS
- A. Install control and electrical power wiring to field-mounted control devices.
- 3.5 STARTUP SERVICE:
- A. Engage a factory-authorized service representative to perform startup service.
1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 4. Verify that cleaning and adjusting are complete.
 5. For direct-drive fans, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.
 6. For belt-drive fans, disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, install belt guards, and adjust belt tension.
 7. Adjust damper linkages for proper damper operation.
 8. Verify lubrication for bearings and other moving parts.
 9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 10. 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.
 11. Shut unit down and reconnect automatic temperature-control operators.
 12. Remove and replace malfunctioning units and retest as specified above.
- 3.6 ADJUSTING
- A. Adjust damper linkages for proper damper operation.

- B. Lubricate bearings.

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. Testing Agency: Contractor will engage a qualified testing agency to perform tests and inspections.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233400

SECTION 233433 - AIR CURTAINS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commercial air-curtain units.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Operation and Maintenance Data: For air curtain units to include in operation and maintenance manuals.

1.3 QUALITY ASSURANCE

- A. AMCA Certification for Fan Aerodynamic Performance Rating: Test, rate, and label, air curtain units in accordance with AMCA 211.
- B. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label, air curtain units in accordance with AMCA 311.
- C. Comply with AHRI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and use.

PART 2 - PRODUCTS

2.1 AIR CURTAIN

- A. Manufacturers
 - 1. Subject to compliance with requirements, provide products by one of the following:
 - a. Berner.
 - b. Mars Air Curtain.
 - c. Powered Aire.
 - 2. Source Limitations: Obtain air curtains from single source from single manufacturer.
- B. Housing:
 - 1. Galvanized Steel: Galvanized steel with electrostatically applied, epoxy-enamel, powder-coat finish.
 - 2. Discharge Nozzle: Integral to housing, containing adjustable air-directional vanes with 40-degree sweep front to back.
- C. Mounting Brackets: Galvanized steel, for wall or ceiling mounting. See schedule for mounting location.
- D. Air-Intake Grilles:
 - 1. Grilles: Integral to, and same material as, housing.
- E. Fans:

1. Centrifugal, forward curved, double width, double inlet.
2. Galvanized steel, Painted steel, or Aluminum.
3. Statically and dynamically balanced.
4. Direct drive.

F. Filters:

1. Washable Panel Filters: Removable, aluminum, baffle-type filters with spring-loaded fastening; with minimum 0.0781-inch-thick, stainless steel filter frame.
2. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

G. Controls:

1. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, Type 1 enclosure.

H. Accessories: Refer to schedules.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine work areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

- A. Install air curtains with clearance for equipment service and maintenance.

3.3 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

3.5 ADJUSTING

- A. Adjust motor speed to achieve specified airflow.
- B. Adjust discharge louver and dampers to regulate airflow.
- C. Adjust air-directional vanes.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. After installing air curtains completely, perform visual and mechanical check of individual components.
 2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-curtain unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain commercial air curtains.

END OF SECTION 233433

SECTION 233713 - AIR DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 1. Rectangular and square ceiling diffusers.
 2. Louver face diffusers.
 3. Linear slot diffusers.
 4. Adjustable blade face registers and grilles.
 5. Fixed face registers and grilles.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 2. Diffuser, Register, and Grille Schedule: Indicate quantity, model number, size, and accessories furnished.
- B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which all diffusers, registers, and grilles are shown. This submittal may be combined with the "Metal Ducts" shop drawing submittal.

PART 2 - PRODUCTS

2.1 GENERAL:

- A. Except as otherwise indicated, provide manufacturer's standard diffusers, registers, and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and provided with accessories as required for a complete installation. Provide diffusers, registers, and grilles of type, capacity, and with accessories and finishes as scheduled on the drawings.

2.2 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Krueger-HVAC; brand of Johnson Controls International plc, Global Products.
 2. METALAIRE, Inc.
 3. Nailor Industries Inc.
 4. Price Industries Limited.
 5. Titus; brand of Johnson Controls International plc, Global Products.
 6. Tuttle & Bailey; brand of Johnson Controls International plc, Global Products.

2.3 LINEAR SLOT DIFFUSERS

- A. Slot diffusers shall be standard one-piece lengths up to 6-feet and shall be furnished in multiple sections greater than 6-feet. Multiple sections shall be joined together end-to-end with alignment pins to form a continuous slot appearance for lengths greater than 6'. All alignment

components shall be provided by the manufacturer. Plenums shall be manufactured by the slot diffuser manufacturer. Plenums shall be internally insulated, by the manufacturer, with minimum 1/4" thick, closed-cell insulation. Insulation shall not be made of fibrous material.

2.4 UNDER FLOOR AIR DISTRIBUTION DIFFUSERS

- A. Under floor air distribution diffusers shall be constructed with a removable core section and casing distributor basket with air flow adjustment device. Diffusers shall be tested in accordance with ANSI/ASHRAE Standard 70-1991. Maximum terminal velocity shall be limited to 50 FPM four feet above the diffuser face.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers are installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.
- D. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove dirt and smudges. Replace any air device that has damaged finishes

3.3 ADJUSTING

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233816 – RANGE HOODS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Range Hoods.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include installation details, material descriptions, dimensions of individual components, and finishes for each appliance.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished accessories.
- B. Operation and Maintenance Data: For each residential appliance to include in operation and maintenance manuals.

1.3 QUALITY ASSURANCE

- A. Electrical Appliances: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 507.

PART 2 - PRODUCTS

2.1 RANGE HOODS

- A. Manufacturers
 - Subject to compliance with requirements, provide products by one of the following:
 - a. Accurex
 - b. Broan-Nutone
 - c. GE Appliances; Haier Group.
 - d. Greenheck.
 - e. Whirlpool Corporation.
 - 2. Source Limitations: obtain all range hoods from single manufacturer.
- B. Type: under cabinet exhaust-hood system.
- C. Exhaust Fan: fan remotely located, with separate housing.
- D. Finish: Stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine walls, ceilings, and roofs for suitable conditions where range hoods will be installed.

3.2 INSTALLATION

- A. Install appliances according to manufacturer's written instructions.

- B. Built-in Equipment: Securely anchor units to supporting cabinets or walls with concealed fasteners. Verify that clearances are adequate for proper functioning and that rough openings are completely concealed.
- C. Exhaust ducts from kitchen range hoods shall be independent of all other exhaust systems.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Perform visual, mechanical, and electrical inspection and testing for each range hood according to manufacturers' written recommendations. Certify compliance with each manufacturer's appliance-performance parameters.
 - 2. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After installation, start units to confirm proper operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and components.
- B. An appliance will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain residential appliances.

END OF SECTION 233816

SECTION 236514 – EVAPORATIVE FLUID COOLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Evaporative Fluid Coolers which are factory-assembled, closed-circuit, induced-draft, counterflow cooling towers.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
 1. Include rated capacities, pressure drop, fan performance data, rating at selected points indicated, and furnished specialties and accessories.
 2. Maximum flow rate.
 3. Minimum flow rate.
 4. Pressure required at cooling tower supply piping connections.
 5. Pressure required at collection basin sweeper supply piping connections.
 6. Drift loss as percent of design flow rate.
 7. Volume of water in suspension for purposes of sizing remote storage.
 8. Sound:
 - a. Sound pressure levels for operation with fan off, fan at minimum speed, and design speed. If sound requirements are indicated at a specific distance, submit performance using same distance for comparative analysis.
 9. Performance curves for varying entering-water temperatures from design to minimum in five-degree temperature increments.
 10. Fan airflow at design conditions, brake horsepower, and drive losses (indicated in horsepower and percent of brake horsepower).
 11. Fan motor electrical characteristics including, but not limited to, speed, voltage, phase, hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
 12. Pump flow rate, head, brake horsepower, and efficiency.
 13. Pump motor electrical characteristics including, but not limited to, speed, voltage, phase, hertz, amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
 14. Electrical power requirements for each cooling tower component requiring power.
- B. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Structural supports.
 2. Piping roughing-in requirements.
 3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
 4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

- C. Field Test Reports: Include startup service reports.
- D. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.3 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
 - 1. All components of cooling tower.
 - 2. Fan assembly including fan, drive, and motor.
 - 3. Warranty Period: Five years from date of Substantial Completion.

1.4 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by CTI.
- B. ASHARE 90.1 – 2016.
- C. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. CTI Certification: Cooling tower thermal performance according to CTI STD 201RS.
- E. Performance Test: Factory test and certify cooling tower performance according to CTI STD 201RS, "Standard for the Certification of Water-Cooling Tower Thermal Performance."

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Coordinate requirements for multi-piece assembly for shipment. Limit the number of separate pieces for field installation to as few as possible.
- B. If factory assembly of multiple pieces is required for testing or other reasons, disassemble cooling tower into major assemblies as required by installation before packaging for shipment.
 - 1. Clearly label each separate package with a unique designation and include with assembly instructions for each complete cooling tower.
 - 2. Install seals on gear-drive assemblies to eliminate oil leakage during shipment if shipped with oil.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Baltimore Aircoil
 - 2. Delta Cooling Towers
 - 3. Marley (SPX Cooling Technologies)

2.2 DESCRIPTION:

- A. Factory assembled closed loop, counterflow design with airflow from all sides and induced-draft, top-mounted axial fan, vertical discharge, and pressurized pipe distribution.

2.3 CASING AND FRAME

- A. Casing Material: Galvanized steel, ASTM A653/A653M, G235 coating.

- B. Frame Material: Galvanized steel, ASTM A653/A653M, G235 coating.
- C. Hardware: Galvanized or stainless steel.
- D. Joints and Seams: Sealed watertight.
- E. Welded Connections: Sealed watertight.

2.4 COLLECTION BASIN

- A. Factory-Assembled Collection Basin:
 - 1. Material: Stainless steel, Grade 304 or Grade 316.
 - 2. Hardware: Galvanized or stainless steel.
 - 3. Joints and Seams: Sealed watertight.
 - 4. Welded Connections: Sealed watertight.
 - 5. Removable stainless-steel strainer with openings smaller than nozzle orifices.
 - 6. Overflow and drain connections.
 - 7. Makeup-water connection.
 - 8. Outlet Connection: Configured to mate to ASME B16.5, Class 150 flange.

2.5 COLLECTION BASIN MAKEUP-WATER ASSEMBLY

- A. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- B. Electric/Electronic, Collection Basin Water-Level Controller with Makeup-Water Valve:
 - 1. Enclosures: NEMA 250, Type 4.
 - 2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip.
 - 3. Electrode Probes: Stainless steel.
 - 4. Makeup-Water Valve:
 - a. Slow closing.
 - b. Valve actuator controlled and powered through level controller in response to water-level set point.
 - c. Actuator Enclosure: NEMA 250, Type 4.
 - d. Fail Position: Last.
 - e. Action: modulating.
 - 5. Electrical Connection Requirements: 120-V ac, single phase, 60 Hz.

2.6 PRESSURIZED DISTRIBUTION NETWORK

- A. Main header and lateral branch piping designed for even distribution over heat-exchanger coils throughout the entire flow range without the need for balancing valves and for connecting individual, easily removable, nonclogging spray nozzles.

2.7 HEAT-EXCHANGER COILS

- A. Tube and Tube Sheet Materials: Copper tube with copper or stainless-steel tube sheet.

B. Heat-Exchanger Arrangement:

1. Serpentine tubes with removable cover plate on inlet and outlet headers or straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube; sloped for complete drainage of fluid by gravity.
2. Tubes with extended surface fins if required to achieve performance indicated.

2.8 DRIFT ELIMINATORS

- A. Material: PVC
- B. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
- C. Arrangement: Multiple, easily removable sections.
- D. Configuration: Multipass, designed and tested to reduce water carryover to 0.001 percent of design flow rate indicated.

2.9 AIR INLET

- A. Air-Intake Louvers:
 1. Material: PVC.
 2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
 3. Multiple, easily removable sections arranged to uniformly direct air into cooling tower, to minimize air resistance, to block direct sunlight, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

2.10 FAN AND DRIVE ASSEMBLY

- A. Axial Fan: Balanced at the factory.
 1. Blade Material: Aluminum.
 2. Hub Material: Aluminum.
 3. Fan Shaft: Stainless steel.
 4. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F. Bearings designed for an L-10 life of 40,000 hours.
 5. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
- B. Fan Motor:
 1. Comply with NEMA MG 1 unless otherwise indicated.
 2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
 3. Motor Enclosure: totally enclosed fan-cooled (TEFC).
 4. Energy Efficiency: NEMA Premium Efficient.
 5. Variable-Speed Motors: Inverter-duty rated per NEMA MG 1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."

6. Motor Shaft Grounding: Motors shall be controlled through variable-frequency controllers with shaft grounding system to protect motor bearings from induced voltage. Drag on motor shaft due to shaft ground system shall be less than 0.5 percent of motor nameplate horsepower.

2.11 RECIRCULATING WATER DISTRIBUTION SYSTEM

- A. Pump: Close-coupled, single-stage, bronze-fitted centrifugal pump; with mechanical seal and suitable for outdoor service. Factory install pump with following:
 1. Flanges at pump connections to piping.
 2. Strainer installed in piping on suction side of pump.
 3. Flow balancing valve in piping on discharge side of pump.
- B. Pump Motor:
 1. Comply with NEMA MG 1 unless otherwise indicated.
 2. Motor Enclosure: totally enclosed.
 3. Energy Efficiency: NEMA Premium Efficient.
- C. Piping: Interconnecting collection basin to pump and pressurization distribution system.
 1. Design delegated to manufacturer.
 2. External to and supported from cooling tower casing and frame.
 3. Install flanges at connections to collection basin and pressurized distribution system.
 4. Drain connection with isolation valve at piping low point if piping does not drain directly into collection basin.
- D. Piping: Field installed for connection to remotely installed pump and water storage that are not furnished with cooling tower.

2.12 ELECTRICAL POWER

- A. Motor Controllers:
 1. NEMA ICS 2, Class A, full-voltage, non-reversing, motor-rated controller.
 2. Configured for control of single- or multispeed motors as indicated.
 3. Enclosure: NEMA 250, Type 4, with hinged full-front access door with lock and key.
 4. Refer to schedules for SCCR rating.
 5. Hand-Off-Auto Switch: Mounted on face of enclosure.
 6. Control Relays: Time-delay relays.
 7. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.

2.13 CONTROLS

- A. Control Package: Factory installed and wired, and functionally tested at factory before shipment.
 1. Standalone and microprocessor based.
 2. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure.

1. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display evaporative fluid cooler status and alarms.
 - a. Hardwired Points, refer to controls diagram.
 - b. ASHRAE 135 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the DDC system for HVAC.

2.14 SERVICE ACCESS

A. Doors:

1. Large enough for personnel to access cooling tower internal components.
2. Doors shall be hinged with handles operable from both sides of the door.
3. Door materials shall match casing.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine cooling towers before installation. Reject cooling towers that are damaged.
- B. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting cooling tower performance, maintenance, and operation.
 1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:
 1. Install cooling towers on cast-in-place concrete equipment bases.
- B. Install anchor bolts to elevations required for proper attachment to supported equipment.
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Maintain clearances required by governing code.
- E. Loose Components: Install components, devices, and accessories furnished by manufacturer with cooling tower, that are not factory mounted.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to cooling towers, allow space for service and maintenance.
- C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
- D. Install drain piping with valve at cooling tower drain connections and at low points in piping.

- E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
- F. Connect to makeup-water connections with shutoff valve, plugged tee with pressure gage, and drain connection with valve and union.
- G. Supply and Return Piping:
 - 1. Connect to entering cooling tower connections with shutoff valve, strainer, balancing valve, thermometer, plugged tee with pressure gage, flow meter, and drain connection with valve.
 - 2. Connect to leaving cooling tower connection with shutoff valve thermometer, plugged tee with full port ball valve for portable field instruments, and drain connection with valve.
 - 3. Make connections to cooling tower with a flange.

3.4 ELECTRICAL POWER CONNECTIONS

- A. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer. Ground all equipment as required by NFPA.

3.5 CONTROLS CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring between cooling towers and other equipment to interlock operation as required to achieve a complete and functioning system.
- C. Connect control wiring between cooling tower control interface and DDC system for remote monitoring and control of cooling towers.
- D. Install label at each termination indicating control equipment designation serving cooling tower and the I/O point designation for each control connection.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Inspect field-assembled components, equipment installation, and piping; controls; and electrical connections for proper assemblies, installations, and connections.
- C. Obtain performance data from manufacturer.
 - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - a. Clean entire unit including basins.
 - b. Verify that accessories are properly installed.
 - c. Verify clearances for airflow and for cooling tower servicing.
 - d. Check for vibration isolation and structural support.
 - e. Lubricate bearings.
 - f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
 - g. Verify pump rotation for correct direction, vibration, cavitation, and flow and correct problems.

- h. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
 - i. Check vibration switch setting. Verify operation.
 - j. Verify water level in tower basin. Fill to proper startup level. Check makeup-water-level control and valve.
 - k. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
 - l. Replace defective and malfunctioning units.
 - D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
 - E. Prepare a written startup report that records the results of tests and inspections.
- 3.7 ADJUSTING
- A. Set and balance water flow to each tower inlet.
 - B. Adjust water-level control for proper operating level.
 - C. Adjust basin heater control for proper operating set point.
- 3.8 DEMONSTRATION
- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236514

SECTION 237416 – PACKAGED AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged air conditioning units with the following components:

1. Casings.
2. Fans, drives, and motors.
3. Energy recovery wheels.
4. Coils.
5. Refrigerant circuit components.
6. Air filtration.
7. Dampers.
8. Electrical power connections.
9. Controls.
10. Accessories.

1.2 SUBMITTALS

A. Product Data: For each Unit.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include rated capacities, dimensions, weight, required clearances, characteristics, furnished specialties, and accessories.
3. Include cabinet material, metal thickness, finishes, insulation, and accessories.
4. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
5. Include certified coil-performance ratings with system operating conditions indicated.
6. Include filters with performance characteristics.
7. Include dampers, including housings, linkages, and operators.

B. System startup reports.

C. Operation and Maintenance Data: For Units to include in emergency, operation, and maintenance manuals.

1.3 MAINTENANCE MATERIAL

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set of filters for each unit.
2. Fan Belts: One set for each belt-driven fan.

1.4 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of unit that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. 1 year parts and labor from date of Substantial Completion.
 - b. 1 year parts and labor from date of Substantial Completion.
 - c. 5 year compressor parts from date of Substantial Completion.
 - d. 5 year Energy Recovery parts from date of Substantial Completion.

1.5 QUALITY ASSURANCE

- A. AHRI Compliance:
 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
 2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
 3. Comply with AHRI 1060 for testing and rating performance for air-to-air heat exchanger.
- B. AMCA Compliance:
 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
 2. Damper leakage tested in accordance with AMCA 500-D.
 3. Operating Limits: Classify according to AMCA 99.
- C. ASHRAE Compliance:
 1. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 2. ASHRAE 15 For refrigeration system safety.
 3. ASHRAE 84 Compliance: Comply with capacity ratings for heat-wheel energy-recovery equipment.
 4. Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
 5. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. NFPA Compliance:
 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
 2. Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- E. UL Compliance: Comply with UL 1995.
- F. MATERIALS
 1. Steel:

- a. ASTM A36/A36M for carbon structural steel.
 - b. ASTM A568/A568M for steel sheet.
- 2. Stainless Steel:
 - a. Manufacturer's standard grade for casing.
 - b. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- 3. Galvanized Steel: ASTM A653/A653M.
- 4. Aluminum: ASTM B209.
- 5. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.
 - a. Standards:
 - 1) ASTM B117 for salt spray.
 - 2) ASTM D2794 for minimum impact resistance of 100 in-lb.
 - 3) ASTM B3359 for cross-hatch adhesion of 5B.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Daikin Applied.
 - 2. Trane.
 - 3. YORK; brand of Johnson Controls International plc, Building Solutions North America.

2.2 UNIT CASINGS

- A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
- B. Construction:
 - 1. Provide manufacturer's standard casing construction, having corrosion protection coating, and exterior finish, with a minimum of 1/2" thick, 1.0 pound density thermal insulation.
 - 2. Casings shall have removable panels or access doors for inspection and access to internal parts, knockouts for electrical and piping connections and an exterior condensate drain connection and lifting lugs.
- C. Condensate Drain Pans:
 - 1. Construction: Stainless steel sheet.
 - 2. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - 3. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.

4. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

2.3 FANS, DRIVES, AND MOTORS

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.
 1. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway.
 2. Shaft Bearings:
 - a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.
 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices.
- C. Drives, Direct: Factory-mounted, direct drive.
- D. Drives, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
 1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards".
- E. Relief-Air Fan: Variable speed, shaft mounted on **permanently lubricated** motor. Refer to schedule for required types.

2.4 ENERGY RECOVERY WHEELS

- A. Assembly:
 1. Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg differential pressure.
 2. Casing seals on periphery of rotor, on duct divider, and on purge section.
 3. Support vertical rotors on grease-lubricated ball bearings with extended grease fittings. Mount horizontal rotors on tapered roller bearing.
- B. Rotor –Aluminum or Polymer: Segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating.

- C. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable-frequency controller. Permanently lubricated wheel bearings.
- D. Controls:
 - 1. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 - 2. Retain one of first three subparagraphs below.
 - 3. Variable-frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.
 - 4. Control energy recovery to permit air economizer operation.
 - a. Bypass dampers to assist energy recovery control.

2.5 COILS

- A. General:
 - 1. Aluminum plate fin and seamless copper tube type.
 - 2. Fins shall have collars drawn, belled and firmly bonded to the tubes by means of mechanical expansion of the tubes. No soldering or tinning shall be used in the bonding process. Coils shall have a galvanized steel casing.
 - 3. Coils shall be mounted in the coil casing with same end connections accessible for service.
 - 4. Coils shall be removable from the unit through the piping enclosure.
 - 5. Coil section shall be completely insulated.
- B. Refrigerant cooling coils:
 - 1. Refrigerant coils shall have an equalizing type vertical distributor to ensure each coil circuit receives the same amount of refrigerant.
 - 2. Coils shall be designed for 300 psig working pressure and pressure tested at 450 psig., then cleaned, dehydrated, and sealed with a holding charge of refrigerant.
- C. Hot Gas Reheat Coil:
 - 1. Provide hot gas reheat coil with staged or modulating control for reheat during dehumidification operation.
 - 2. Hot gas reheat coil shall maintain space temperature when unit is operating in the dehumidification mode. Refer to control drawings.
- D. Electric Heat Sections:
 - 1. Provide electric heat coils, of manufacturer's standard construction, factory-wired for single point wiring connection, complete with over-current and over-heat protection devices.

2.6 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Refer to schedules.

2.7 AIR FILTRATION

- A. Filters:
 - 1. Description: Factory-fabricated, self-supported, disposable air filters with holding frames.
 - 2. Efficiency: Refer to schedule.

2.8 DAMPERS

- A. Outdoor- and Return-Air Dampers: Low-leakage, per ASHRAE 90.1 standards.
- B. Electronic Damper Operators:
 - 1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - 3. Operator Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements.
 - b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - 4. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - 5. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.

2.9 ELECTRICAL POWER CONNECTIONS

- A. Refer to equipment schedules and electrical drawings.

2.10 CONTROLS

- A. Basic Unit Controls:
 - 1. Unit controls shall come factory mounted unless otherwise noted on controls drawings. Coordinate with manufacturer's provided control points and Controls Contractor to meet design intent.
 - 2. Control-voltage transformer.
- B. DDC Controller:
 - 1. Controller shall have volatile-memory backup.
 - 2. Safety Control Operation:
 - a. Smoke Detectors: Stop fan and close outdoor-air damper if smoke is detected. Provide additional contacts for alarm interface to fire alarm control panel.
 - b. Low-Discharge Temperature: Stop fan and close outdoor-air damper if supply air temperature is less than 40 deg F.
 - c. Defrost Control for Condenser Coil: Pressure differential switch to initiate defrost sequence.
 - 3. Scheduled Operation: refer to controls drawings and coordinate with owner.
- C. Interface Requirements for HVAC Instrumentation and Control System:
 - 1. Interface relay for scheduled operation.
 - 2. Interface relay to provide indication of fault at the central workstation and diagnostic code storage.
 - 3. Provide BACnet compatible interface.

2.11 ACCESSORIES

- A. Refer to schedule options and notes.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of packaged units.
- B. Examine roughing-in for Units to verify actual locations of piping and duct connections before equipment installation.

3.2 INSTALLATION

- A. Unit Support: Install unit level on structural curbs or steel supports per details. Coordinate wall penetrations and flashing with wall construction. Secure Unit to structural support with anchor bolts.

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to Unit, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.

3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 1. Install ducts to termination at top of roof curb.
 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 3. Connect supply ducts to Units with flexible duct connectors.
 4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring and ground equipment.
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
 1. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.

2. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Exhaust-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
3. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.8 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing packaged units and air-distribution systems and after completing startup service, clean Units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 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. Unit will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

END OF SECTION 237416

SECTION 238123 –COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes computer-room air-conditionings, including the following:

- 1. Indoor units.
- 2. Outdoor units.

1.2 SUBMITTALS

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

- 1. Include material descriptions, dimensions of individual components and profiles, and finishes for computer-room air-conditioning units.
- 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.3 MAINTENANCE MATERIAL

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

- 1. Filters: One set(s) of filters for each unit.

1.4 QUALITY CONTROL

- A. ASHRAE/IES Compliance:

- 1. Applicable requirements in ASHRAE/IES 62.1.
- 2. Applicable requirements in ASHRAE/IES 90.1.

- B. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

- 1. Above Air.
- 2. Liebert, Vertiv Holdings Co.
- 3. Stulz-ATS.

2.2 INDOOR UNITS

- A. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, refrigeration circuits, coils, filters, humidifiers, and controls.
- B. Cabinet and Frame: Welded tubular-steel frame with removable single-thick steel panels and insulated with duct liner.

1. Floor Stand: Welded tubular steel, 6 inches high, with adjustable leg. Refer to vibration isolation specification for additional requirements.
- C. Supply-Air Fan:
1. Plenum, single inlet, direct drive, electronically commutated, and variable speed.
- D. Refrigeration System:
1. Compressor: Scroll, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
 - a. Two independent circuits.
 - b. Low-pressure switch.
 - c. Manually reset, high-pressure switch.
 - d. Thermal-expansion valve with external equalizer.
 - e. Sight glass with moisture indicator.
 - f. Service shutoff valves.
 - g. Charging valves.
 - h. Hot-gas bypass.
 - i. Refrigerant charge.
 2. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
 - a. Mount stainless-steel drain pan having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir under coil assembly.
- E. Filter: Disposable, pleated, glass-fiber media.
- F. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
 2. Control: Fully modulating to provide gradual modulation from zero to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
 3. Drain Cycle: Field-adjustable drain duration and drain interval.
- G. Control System:
1. Microprocessor unit-mounted panel.
 2. Refer to controls drawings for additional requirements.
- 2.3 OUTDOOR UNITS
- A. Remote Air-Cooled Refrigerant Condenser:
1. Integral, copper-tube aluminum-fin coil.
 2. Condenser with surge protection device (SPD) and locking disconnect in the enclosed electrical panel section.

- B. Fan: Direct-drive, single-speed centrifugal type.
- C. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Layout and install computer-room air conditioners and suspension system coordinated with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Install computer-room air conditioners coordinated with computer-room access flooring Installer.
- C. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to computer-room air conditioners, allow space for service and maintenance.
- C. Water and Drainage Connections: Provide adequate connections for condensate drain and humidifier flushing system.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.
- D. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes split system air conditioners, including the following:
 1. Indoor Air Handler.
 2. Outdoor Units.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.3 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One set(s) for each air-handling unit.

1.4 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."
 3. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
 4. Refrigerant Coils: Comply with ARI 206/110.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Carrier Global Corporation.
 2. Daikin Applied.
 3. Lennox.
 4. Trane.
 5. YORK; brand of Johnson Controls International plc, Building Solutions North America.

2.2 INDOOR AIR HANDLER

- A. Cabinet: Steel, with duct liner.
 - 1. Duct Liner: Fiberglass, minimum 1/2 inch thick, complying with ASTM C1071 and having a coated surface exposed to airstream complying with NFPA 90A or NFPA 90B and with NAIMA's "Fibrous Glass Duct Liner Standard."
 - 2. Factory paint external cabinets in manufacturer's standard color.
- B. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
- C. Electric-Resistant Heating Elements: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports.
- D. Heating-Element Control: Sequencer relay with relay for each element; switches elements on and off, with delay between each increment; initiates, stops, or changes fan speed.
- E. Summer Fan Switch: Connected to permit independent on-off switch of unit fan.
- F. Disposable Filters: fiberglass media in sheet metal frame.
- G. General Refrigeration Component Requirements:
 - 1. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
- H. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Match size with furnace. Include condensate drain pan with accessible drain outlet.
 - 1. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.
- I. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.

2.3 OUTDOOR UNITS

- 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 with crankcase heater. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler.
 - 3. Heat-Pump Components: 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.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Equipment Mounting:
 - 1. Install ground-mounted, compressor-condenser components on cast-in-place concrete equipment base(s).
- D. 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.
- C. Duct Connections: Drawings indicate the general arrangement of ducts. Connect supply ducts to split-system air-conditioning units with flexible duct connectors.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- 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. Measure and record airflows.
 - 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 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 238126

SECTION 238146 - WATER-SOURCE HEAT PUMPS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes unitary heat pumps with refrigerant-to-water heat exchangers, refrigeration circuits, and refrigerant compressor(s).

1.2 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include material descriptions, dimensions of individual components and profiles, and finishes for each water-source unitary heat pump.
 - 2. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Operation and Maintenance Data: For water-source unitary heat pumps to include in emergency, operation, and maintenance manuals.

1.3 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: One set(s) for each air-handling unit.

1.4 QUALITY ASSURANCE

- A. ASHRAE
 - 1. ASHRAE 15.
 - 2. ASHRAE 62.1 - 2016
 - 3. ASHRAE 90.1 - 2016
- B. ASTM RATINGS
 - 1. C1071
 - 2. G21
- C. Comply with NFPA 70.
- D. Comply with safety requirements in UL 484 for assembly of free-delivery, water-source heat pumps.
- E. UL Rating 181.

PART 2 - PRODUCTS

2.1 WATER SOURCE HEAT PUMP

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bosch.
 - 2. Climate Master
 - 3. Daikin Applied.
 - 4. Trane.

5. YORK; brand of Johnson Controls International plc, Building Solutions North America.
- B. Description: Packaged water-source unitary heat pump with temperature controls; factory assembled, piped, wired, tested, and rated according to ASHRAE/ARI/ISO-13256-1.
- C. Cabinet and Chassis: Galvanized-steel casing with the following features:
 1. Access panel for access and maintenance of internal components.
 2. Knockouts for electrical and piping connections.
 3. Cabinet Insulation: Glass-fiber liner, minimum 1/2 inch, thick
- D. Water Circuits:
 1. Refrigerant-to-Water Heat Exchangers:
 - a. coaxial heat exchangers with copper water tube, with enhanced heat-transfer surfaces inside a steel shell; both shell and tube are leak tested to 600 psig on refrigerant side and 500 psig on water side.
- E. Refrigerant Circuit Components:
 1. Sealed Refrigerant Circuit: Charge with R-454B or R32 refrigerant.
 2. Filter-Dryer: Factory installed to clean and dehydrate the refrigerant circuit.
 3. Charging Connections: Service fittings on suction and liquid for charging and testing on each circuit.
 4. Reversing Valve: Four-way, solenoid-activated valve designed to be fail-safe in heating position with replaceable magnetic coil.
 5. Compressor:
 - a. Scroll.
 - b. Installed on vibration isolators and mounted on a structural steel base plate and full-length channel stiffeners.
 - c. Exterior of compressor shall be wrapped with a high-density sound-attenuating blanket and housed in an acoustically treated enclosure.
 - d. Factory-Installed Safeties:
 - 1) Antirecycle timer.
 - 2) High-pressure cutout.
 - 3) Low-pressure cutout or loss of charge switch.
 - 4) Internal thermal-overload protection.
 - 5) Freezestat to stop compressor if water-loop temperature in refrigerant-to-water heat exchanger falls below 35 deg F.
 - 6) Water-coil, low-temperature switch.
 6. Refrigerant Piping Materials: ASTM B743 copper tube with wrought-copper fittings and brazed joints.
 7. Pipe Insulation: Refrigerant minimum 3/8-inch-thick, flexible elastomeric insulation on piping exposed to airflow through the unit. Maximum 25/50 flame-spread/smoke-developed indexes according to ASTM E84.

8. Refrigerant Metering Device: Dual-port, thermal-expansion valve to allow specified operation with entering-water temperatures from 25 to 120 deg F
9. Units charged with 62 ounces or greater of refrigerant shall be supplied with a Refrigerant Detection System (RDS) with sensors to be strategically placed within the cabinet. In the event of a refrigerant leak, the RDS disables compressor operation, and the unit blower runs to disperse any concentration of leaked refrigerant in compliance with UL 60335-2-40 safety standards for flammable refrigerants.

F. Controls:

1. Basic Unit Control Modes and Devices:
 - a. Unit shutdown on high or low refrigerant pressures.
 - b. Unit shutdown on low water temperature.
 - c. Low- and high-voltage protection.
 - d. Overcurrent protection for compressor.
 - e. Random time delay, three to 10 seconds, start on power-up.
 - f. Time delay override for servicing.
 - g. Control voltage transformer.
 - h. Water-coil freeze protection (selectable for water or antifreeze).
 - i. Automatic intelligent reset. Unit shall automatically reset five minutes after trip if the fault has cleared. Should a fault reoccur three times sequentially, lockout requiring manual reset occurs.
 - j. Ability to defeat time delays for servicing.
 - k. The low-pressure switch shall not be monitored for the first 90 seconds after a compressor start command to prevent nuisance safety trips.
 - l. Remote fault-type indication at thermostat.
 - m. Selectable 24-V dc or pilot duty dry contact alarm output.
 - n. 24-V dc output to cycle a motorized water valve with compressor contactor.
 - o. Service test mode for troubleshooting and service.
 - p. Unit-performance sentinel warns when heat pump is running inefficiently.
 - q. Compressor soft start.
2. DDC interface requirements as described in DDC controls specification section and Mechanical controls sheets.
 - a. Interface relay for scheduled operation.
 - b. Interface relay to provide indication of fault at central workstation.
 - c. Provide BAC-net interface for central DDC workstation

G. Electrical Connection: Single electrical connection.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Equipment Mounting:
 - 1. Where specified on schedules, install water-source, unitary heat pumps on manufacturers stand for downward discharge into under floor plenum.
 - 2. Where specified on schedules Suspend water-source, unitary heat pumps from structure with all-thread hanger rods and spring hangers.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install electrical devices furnished by manufacturer but not specified to be factory mounted.
- C. Install piping adjacent to machine to allow space for service and maintenance.
- D. Duct Connections: Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections:
 - 1. After installing water to water heat pumps and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Heat pumps will be considered defective if they do not pass tests and inspections. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. Perform startup service. Complete installation and startup checks according to manufacturer's written instructions.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain water-source unitary heat pumps.

END OF SECTION 238146

SECTION 238239 - UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Electric Wall, Ceiling, and Suspended Heaters.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

- A. ASHRAE
 - 1. 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
 - 2. 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- B. Factory-assembled and -tested unit complying with AHRI 440.
- 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. Underwriters Laboratory:
 - 1. Comply with UL 2021.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Berko; Marley Engineered Products.
 - 2. Chromalox, Inc.
 - 3. Marley Engineered Products.
 - 4. Modine.
 - 5. Raywall.
 - 6. Reznor.
 - 7. Runtal.
 - 8. QMark; Marley Engineered Products.
 - 9. Trane.

2.2 ELECTRIC WALL, CEILING, AND SUSPENDED HEATERS

- A. Materials
 - 1. Wall and Ceiling Units:

- a. Front Panel: Removable panels fastened with tamperproof fasteners.
 - b. Recessed-Mounted Cabinet Enclosure: Steel with finish to match cabinet. See mechanical schedule for color.
- 2. Suspended Units:
 - a. Discharge Louver: Adjustable fin diffuser for horizontal units
 - b. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
 - c. Finish: Baked enamel over baked-on primer.
- B. Coils
 - 1. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection.
- C. Controls
 - 1. Wall and Ceiling: Controls shall be concealed behind a removable cover.
 - 2. Suspended: Controls shall be unit mounted.
- D. Electrical Connection: Factory wire motors and controls for a single electrical connection.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install suspended unit heaters from structure with all-thread hanger rods and elastomeric hangers.
- B. Install unit heaters level and plumb.

3.3 FIELD QUALITY CONTROL

- A. Perform the following 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 safety devices. Replace damaged and malfunctioning controls and equipment.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

END OF SECTION 238239

SECTION 260010 - SUPPLEMENTAL REQUIREMENTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Supplemental requirements applicable to Work specified in Division 26.

B. Definitions:

1. Voltage Class: For specified circuits and equipment, voltage classes are defined as follows:
 - a. Control Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is supplied from a battery or other Class 2 or Class 3 power-limited source.
 - b. Line Voltage: (1) (controls) Designed to operate using the supplied low-voltage power without transformation. (2) (transmission lines, transformers, SPDs) The line-to-line voltage of the supplying power system.
 - c. Extra-Low Voltage: Not having electromotive force between any two conductors, or between a single conductor and ground, exceeding 30 V(ac rms), 42 V(ac peak), or 60 V(dc).
 - d. Low Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 30 V but not exceeding 1000 V.
 - e. Medium Voltage: Having electromotive force between any two conductors, or between a single conductor and ground, that is rated about 1 kV but not exceeding 69 kV.
 - f. High Voltage: (1) (circuits) Having electromotive force between any two conductors, or between a single conductor and ground, that is rated above 69 kV but not exceeding 230 kV. (2) (safety) Having sufficient electromotive force to inflict bodily harm or injury.

1.2 SCOPE OF WORK

- A. The Electrical Scope of Work (the Work) is generally described by these Specifications and the Drawings numbered with prefixes E, but the Work also includes all such work indicated in **all** of the Contract Documents, including, but not limited to: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Interiors, Equipment, Kitchen, Structural, Mechanical, and Plumbing Drawings and Specifications; and all Addenda.
- B. The Work shall include providing a complete, functional system, including each element of the system as specified, indicated, or reasonably inferred by the Drawings or these Specifications. Provide every article, device, or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the

equipment specified. Elements of the Scope of Work include, but are not limited to, materials, labor, supervision, supplies, tools, equipment, transportation, and utilities.

- C. Drawings are graphic representations of the Work. They show the materials and their relationship to one another, including sizes, shapes, locations, and connections, and the general arrangement of equipment, fixtures, outlets, and circuits. The Drawings may not show exact details about elevations, offsets, control lines, and installation requirements. Use the Drawings as a guide when laying out the Scope of Work to ensure materials and equipment will fit into the designated spaces and will result in a complete, coordinated, and properly operating system when installed per the manufacturer's instructions.

1.3 CODES, REFERENCES, AND STANDARDS

- A. The Work shall comply at a minimum with National Fire Protection Association (NFPA) codes, state and local building codes, and all other applicable codes and ordinances in force, including performance, workmanship, equipment, and materials. Where conflicts between the various codes, ordinances, rules, and regulations exist, comply with the most stringent. Wherever requirements of the Contract Documents exceed those of the above items, the Contract Documents shall govern.
- B. Code compliance, at a minimum, is mandatory. Construe nothing in the Construction Documents as permitting work without compliance with Code. Bring all conflicts observed between Code and the Contract Documents to the Architect's and Engineer's attention immediately. Contractor will be held responsible for any violation of the law.
- C. Obtain inspections by the authorities having jurisdiction. Upon completion of the Work, obtain and deliver to the Owner executed final certificates of acceptance from the authorities having jurisdiction.
- D. Comply with rules and regulations of public utilities and municipal departments affected by the connection of services.
- E. Perform all electrical work in compliance with applicable safety regulations, including OSHA regulations. Provide all safety lights, guards, and warning signs required for the performance of the electrical work.
- F. Obtain and pay for all permits, licenses, and fees that are required by the governing authorities for the performance of the electrical work.

1.4 COORDINATION

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

3. Coordinate interruption with systems impacted by outage including, but not limited to, the following:
 - a. Exercising generators.
 - b. Emergency lighting.
 - c. Elevators.
 - d. Fire-alarm systems.
- B. Arrange to provide temporary electrical power in accordance with requirements specified in Division 01.
- C. Sequence, coordinate, and integrate installing electrical materials and equipment to achieve an efficient workflow. Coordinate the installation and positioning of large equipment in the early stages of the project and prior to the building closure.
- D. Coordinate locations of access panels for electrical items that are being concealed by finished surfaces. The locations of these access panels shall be coordinated and proposed to ensure that all electrical equipment are accessible.
- E. Where electrical identification devices are applied to field-finished surfaces, coordinate the installation of these devices with the completed finished surfaces.
- F. Where acoustical ceilings and similar finishes will conceal the electrical devices, coordinate the installation of these items before ceiling installation.

1.5 PREINSTALLATION MEETINGS

- A. Electrical Preconstruction Conference: Schedule conference with Architect and Owner, not later than 10 days after notice to proceed. Agenda topics include, but are not limited to, the following:
 1. Electrical installation schedule.
 2. Status of power system studies.
 3. Value analysis proposals and any requests for substitution of electrical equipment.
 4. Utility work coordination and class of service requests.
 5. Commissioning activities.

1.6 SEQUENCING

- A. Conduct and submit results of power system studies before submitting Product Data and Shop Drawings for electrical equipment.

1.7 SUBMITTALS

- A. Generally: Submit for approval, manufacturers' technical literature, shop and construction drawings and other submittals required by the Specification. These documents shall be provided prior to ordering equipment and executing any related work on site.

- B. Product Data: Submit for approval detailed product data such as model number, all relevant ratings, country of origin, interface details as necessary, covers and main supports. A specifications compliance sheet shall be provided for each product, indicating if the proposed product comply/does not comply with each article of the related specification section.
- C. Calculations: Submit for approval the manufacturer/supplier calculations for the following systems, prior to ordering/manufacturing the material:
 - 1. Circuit breakers selectivity and discrimination calculation study for a full selective and discriminated distribution scheme.
 - 2. Generators sizing calculations.
 - 3. Rating / derating calculations for the specified equipment.
 - 4. Harmonic analysis.
 - 5. Relay settings.
 - 6. Any other calculations required to comply with the specifications or mentioned in any other sections of the specifications.
- D. Shop and Construction Drawings:
 - 1. Dimensioned plans and sections or elevation layouts of electrical equipment, as applicable.
 - 2. Shop and construction drawings must demonstrate that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings shall clearly state the name and location of the work, the names of Engineer and Contractor, submission date, cross-references to the drawings and specification and the specific reference number, location, service and function of each item.
 - 3. Drawings shall include but not be limited to the following:
 - a. Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for floors.
 - b. Composite construction drawings fully dimensioned showing locations of cables, conduits, cable trays, bus ducts, shafts, mechanical and electrical equipment rooms, ceiling spaces and all other critical locations.
 - c. Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
 - d. Plans, sections and elevations of electrical spaces to illustrate compliance with standards for space allocation for clearances, maintenance, installation, etc.
- E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements and arrange for certification by manufacturer / manufacturer's authorized representative.
- F. Assembled Equipment: Any assembled equipment to be supplied for the project shall be factory assembled by the manufacturer.
- G. Test Certificates and Reports: Submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results shall be submitted in clearly identified and organized booklets, indicating item of equipment, make, model, type, date of tests, type of tests, descriptions and procedures. Include in the test reports the Quality Assurance Certification, the standards to which the equipment comply, and the standards to which the equipment was tested.

- H. Labeling Schedule: Submit for approval, prior to installation, a schedule of all equipment and devices to be labeled and the suggested details, lettering, position and fixing methods of each label indicating its application.
- I. As-Built (Record) Drawings: Prior to substantial Completion, submit Record Drawings certified by the Engineer of record on installed electrical systems, in accordance with requirements of the Specification. The As-Built (Record) Drawings, where applicable, shall include data on existing works. The As-Built Records shall be made progressively as the Work proceeds.
- J. Facility EPM Program Binders:
 - 1. Complete Set: On USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
 - 2. Volumes 2 and 8: Reproducible hardcopy on archival quality, 28 lb (105 GSM), acid-free, bond paper.
- K. Operation and Maintenance Data:
 - 1. Provide emergency, operation, and maintenance manuals for each system, equipment, and device listed below:
 - a. Switchgear.
 - b. Switchboards.
 - c. Generators.
 - d. Automatic Transfer Switches.
 - e. Automatic Load Control Relays.
 - f. Lighting Control Panels.
 - 2. Include the following information:
 - a. Manufacturer's operating specifications.
 - b. User's guides for software and hardware.
 - c. Schedule of maintenance material items recommended to be stored at Project site.
 - d. Detailed instructions covering operation under both normal and abnormal conditions.
 - e. Time-current curves for overcurrent protective devices and manufacturer's written instructions for testing and adjusting their settings.
 - f. List of load-current and overload-relay heaters with related motor nameplate data.
 - g. List of lamp types and photoelectric relays used on Project, with ANSI and manufacturers' codes.
 - h. Manufacturer's instructions for setting field-adjustable components.
 - i. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.
 - j. EPSS: Manufacturer's system checklists, maintenance schedule, and maintenance log sheets in accordance with NFPA 110.
 - k. Exterior pole inspection and repair procedures.
- L. Software and Firmware Operational Documentation: Provide software and firmware operational documentation in Facility EPM Program Binders, including the following:
 - 1. Software operating and upgrade manuals.

2. Names, versions, and website addresses for locations of installed software.
3. Device address list.
4. Printout of software application and graphic screens.
5. Testing and adjusting of panic and emergency power features.
6. For lighting controls include the following:
 - a. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
 - b. Operation of adjustable zone controls.

M. Software:

1. Program Software Backup: Provide username and password for approved online or cloud solution and USB media that is clearly and permanently labeled with attached placard on lanyard to prevent misplacement.
2. Provide to Owner upgrades and unrestricted licenses for installed and backup software, including operating systems and programming tools required for operation and maintenance.

1.8 QUALITY ASSURANCE

- A. Execute the Work in a thorough and professional manner by competent and experienced workmen duly trained to perform the Work.
- B. Install all the Work per the manufacturer's requirements, recommendations, and installation instructions, unless the Contract Documents exceed those requirements. Install all equipment and materials in a neat and professional manner—aligned, leveled, and adjusted for satisfactory operation—in accordance with NECA standards.
- C. Unless indicated otherwise in the Contract Documents, provide new equipment and materials of the best quality and design, free from defects and imperfections, and with markings or a nameplate identifying the manufacturer. Provide all equipment and materials of the same type from the same manufacturer whenever practicable.

1.9 QUALIFICATIONS

- A. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering.
- B. Electrical Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in electrical engineering, including electrical power system modeling and analysis of electrical safety in accordance with NFPA 70E.
- C. Lighting Professional Engineer: Professional engineer possessing active qualifications in accordance with Section 014000 "Quality Requirements" and the following:
 1. Expertise in electrical engineering, lighting design, and structural requirements for exterior poles and standards.

2. Lighting Certified (LC) Professional by the National Council on Qualifications for the Lighting Professions (NCQLP).
-
- D. Welder: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," with training and certification in accordance with AWS D1.1/D1.1M and AWS D1.2/D1.2M.
 - E. Medium-Voltage Duct Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with installation of medium-voltage duct banks in accordance with electrical utility service provider's requirements.
 1. Medium-voltage duct Installer must be approved by North Georgia E.M.C.
 - F. Electrical Power Monitoring Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by manufacturer prior to starting installation.
 - G. EVSE Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by EVSE manufacturer prior to starting installation.
 - H. Generator Set Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired certified Installer credentials issued by generator set manufacturer prior to starting installation.
 - I. Lightning Protection System Installers: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," and able to present unexpired UL-Listed Installer, UL Category Control Number OWAY, credentials prior to starting installation.
 - J. Low-Voltage Electrical Testing and Inspecting Agency: Entities possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site electrical testing supervisors must have documented certification and experience with testing electrical equipment in accordance with NETA testing standards.
 - K. Control-Voltage Electrical Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 1. On-site control-voltage testing supervisor must have BICSI Registered Communications Distribution Designer certification and documented training and experience with testing control-voltage equipment in accordance with NETA testing standards.
 - L. Structural Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing structural concrete, seismic controls, and wind-load controls.
 - M. Outdoor Pole Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience in accordance with ASTM C1093 for foundation testing and inspections.

- N. Luminaire Photometric Testing Laboratory: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" accredited under the NVLAP for Energy Efficient Lighting Products, and complying with applicable IES testing standards.
- O. Lighting Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing and inspecting lighting installations in accordance with IES LM-5.

1.10 FIELD CONDITIONS

- A. Modeling, analysis, product selection, installation, and quality control for Work specified in Division 26 must comply with requirements specified in Section 260011 "Facility Performance Requirements for Electrical."

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. Contractor is responsible for sequencing and scheduling power system studies and electrical equipment procurement. After the Electrical Preconstruction Conference, insufficient lead time for electrical equipment delivery will not be considered a valid reason for substitution.

2.2 FACILITY ELECTRICAL PREVENTIVE MAINTENANCE (EPM) PROGRAM BINDERS

- A. Description: Set of binders containing operation and maintenance data for facility's electrical equipment that was compiled during analysis of installed electrical Work for Facility EPM Program development.
- B. Applicable Standards:
 - 1. Regulatory Requirements: Comply with recommendations in NFPA 70B.
 - 2. General Characteristics:
 - a. Volume 1 - Introduction:
 - 1) Summarize how Facility EPM Program Analysis was performed, how data were collected, and how volumes are organized.
 - 2) Describe Facility EPM Program and provide recommended policies and procedures for implementing the program and keeping it current.

- 3) Provide place for Owner to identify contact information for employees responsible for implementing and maintaining Facility EPM Program.
- b. Volume 2 - Facility Safety, Hazards Awareness, and Emergency Procedures:
- 1) Include training requirements for employees and contractors.
 - 2) Include list of known facility hazards impacting IT&R activities.
 - 3) Include approval and permitting procedures for IT&R activities.
 - 4) Include incident emergency response procedures.
 - 5) Include emergency shutdown procedures.
 - 6) Include electrical disaster recovery procedures.
- c. Volume 3 - Operating Procedures for Electrical Equipment and Controls:
- 1) Generators.
 - 2) Automatic Transfer Switches.
- d. Volume 4 - Facility Diagrams and Schedules:
- 1) Include single-line diagrams.
 - 2) Include grounding and bonding diagrams.
 - 3) Include essential wiring diagrams.
 - 4) Include system automation diagrams (SCADA, BMS, lighting, HVAC, etc.).
 - 5) Include records of switchgear, switchboard, and panelboard schedules.
 - 6) Include time-current curves for overcurrent protective devices.
 - 7) Include list of load-current and overload-relay heaters with related motor nameplate data.
- e. Volume 5 - Inventory of Facility Equipment Using Electrical Power:
- 1) Include simplified floor plans showing equipment locations.
 - 2) Identify critical equipment (electrical or otherwise).
 - 3) Include identifying designations and nameplate data.
 - 4) Include warranty and maintenance contract information.
- f. Volume 6 - Inventory of Facility Tools, Supplies, and Personnel Protective Equipment:
- 1) Include schedules of maintenance material items recommended to be stored at facility.
 - 2) Include list of lamp types and photoelectric relays used in facility with ANSI and manufacturers' codes.
 - 3) Include calibration and servicing data for each item.
- g. Volume 7 - Inspection, Testing, and Repair (IT&R) Plan:
- 1) Include tables showing frequency of activities for each item.
 - 2) Include annual schedule with activities mapped to specific days of the year.
 - 3) Include exterior pole inspection and repair procedures.
- h. Volume 8 - Inspection, Testing, and Repair (IT&R) Forms:

- 1) Switchgear.
 - 2) Switchboards.
 - 3) Generators.
 - 4) Automatic Transfer Switches.
 - 5) Automatic Load Control Relays.
 - 6) Lighting Control Panels.
- i. Volume 9 - Inspection, Testing, and Repair (IT&R) Procedures:
- 1) Switchgear.
 - 2) Switchboards.
 - 3) Generators.
 - 4) Automatic Transfer Switches.
 - 5) Automatic Load Control Relays.
 - 6) Lighting Control Panels.
- j. Volume 10 - Spare Parts List:
- 1) Include list of all parts required to perform IT&R procedures.
 - 2) Identify quantities of which parts are recommended to be stored on-site.
 - 3) Include source contact information and budget cost for each item.
- k. Volume 11 - Construction Project Closeout Record Documentation:
- 1) Include records of power system studies and photometric studies.
 - 2) Include records of risk assessment studies.
 - 3) Include records of electrical system startup and commissioning activities.
 - 4) Include records of baseline inspections and tests.
 - 5) Include records of baseline infrared photographs with normal light photographs showing the location, direction, angle, and conditions necessary for reproducing each infrared photograph.
 - 6) Include records of baseline settings for adjustable equipment and devices.

PART 3 - EXECUTION

3.1 PERMITS

- A. Secure and pay for all permits required in connection with the installation of the electrical scope of work. Coordinate with the electrical utility companies for the installation and connection of electrical utilities. Pay all charges associated with utility connection, including but not limited to inspection fees, connection charges, utility design fees, etc., except where these services or fees are designated to be provided by others.

3.2 DEVELOPMENT OF FACILITY EPM PROGRAM

- A. Conduct Facility EPM Program analysis in accordance with NFPA 70B recommendations.

- B. Compile operation and maintenance data from Facility EPM Program analysis and submit Facility EPM Program Binders.

3.3 INSTALLATION OF ELECTRICAL WORK

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' written instructions, comply with NFPA 70 and NECA NEIS 1 for installation of Work specified in Division 26. Consult Architect for resolution of conflicting requirements.

3.4 FIELD QUALITY CONTROL

- A. Administrant for Low-Voltage Electrical Tests and Inspections:
 - 1. Administer and perform tests and inspections.
- B. Administrant for Control-Voltage Electrical Tests and Inspections:
 - 1. Administer and perform tests and inspections.
- C. Administrant for Structural Tests and Inspections:
 - 1. Administer and perform tests and inspections.

3.5 CLOSEOUT ACTIVITIES

- A. Training:
 - 1. Train Owner's maintenance personnel on the following topics:
 - a. How to implement Facility EPM Program.
 - b. How to operate normal and emergency electrical systems, including justifications for, and limitations of, protective device settings recommended in study report specified in Section 260573.16 "Coordination Studies."
 - c. How to adjust, operate, and maintain devices specified in Section 260923 "Lighting Control Devices."
 - d. How to adjust, operate, and maintain equipment specified in Section 262300 "Low-Voltage Switchgear."
 - e. How to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories specified in Section 262413 "Switchboards."
 - f. How to adjust, operate, and maintain equipment specified in Section 263213.13 "Diesel-Engine-Driven Generator Sets."
 - g. How to adjust, operate, and maintain transfer switches and related equipment, including ground-fault protection system, specified in Section 263600 "Transfer Switches."
 - h. How to adjust, operate, and maintain devices specified in Section 264313 "Surge Protective Devices for Low-Voltage Electrical Power Circuits."

END OF SECTION 260010

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Copper building wire.
 - 2. Aluminum building wire.
 - 3. Metal-clad cable, Type MC.
 - 4. Connectors and splices.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Field Quality-Control Test Reports

1.3 DEFINITIONS

- A. Homerun: The portion of an electrical circuit between the panelboard and the first device (junction box, receptacle, switch, termination box, etc.). Where MC Cable is allowed, the first device shall be a junction box in an accessible ceiling space above and/or adjacent to the first load in the circuit.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. The following standards shall apply to all products listed:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

2.2 COPPER BUILDING WIRE

- A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. [Alpha Wire; brand of Belden, Inc.](#)
2. [Belden Inc.](#)
3. Cerro Wire LLC.
4. [Encore Wire Corporation.](#)
5. [General Cable; Prysmian Group North America.](#)
6. [Okonite Company \(The\).](#)
7. [Service Wire Co.](#)
8. [Southwire Company, LLC.](#)
9. [WESCO.](#)

C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

2.3 ALUMINUM BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn aluminum current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. [Alpha Wire; brand of Belden, Inc.](#)
2. [Belden Inc.](#)
3. [Encore Wire Corporation.](#)
4. [General Cable; Prysmian Group North America.](#)
5. [Okonite Company \(The\).](#)
6. [Southwire Company, LLC.](#)
7. [WESCO.](#)

C. Conductors: Aluminum, complying with ASTM B800 and ASTM B801.

D. Conductor Insulation:

1. Type THHN and Type THWN-2: Comply with UL 83.
2. Type XHHW-2: Comply with UL 44.

2.4 METAL-CLAD CABLE, TYPE MC

A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.

B. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. [AFC Cable Systems; Atkore International.](#)

2. [Alpha Wire; brand of Belden, Inc.](#)
3. [Belden Inc.](#)
4. Cerro Wire LLC.
5. [Encore Wire Corporation.](#)
6. [General Cable; Prysmian Group North America.](#)
7. [Okonite Company \(The\).](#)
8. [Southwire Company, LLC.](#)
9. [WESCO.](#)

C. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. Comply with UL 1569.
3. Within the healthcare occupancy, **all** MC cable shall be type HCF, suitable for use in patient care areas.

D. Circuits:

1. Single circuit.

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.

2.5 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. [3M Electrical Products.](#)
2. [ABB, Electrification Business.](#)
3. [AFC Cable Systems; Atkore International.](#)
4. [Gardner Bender.](#)
5. [Hubbell Utility Solutions; Hubbell Incorporated.](#)
6. [ILSCO.](#)
7. [Ideal Industries, Inc.](#)
8. [NSi Industries LLC.](#)

9. [O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.](#)
 10. [Service Wire Co.](#)
 11. [TE Connectivity Ltd.](#)
- C. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
1. Material: Copper or Aluminum, to match conductor material.
 2. Type: One hole with standard barrels.
 3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders:
1. Base Bid: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
 2. Alternate: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Conductors must be solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits:
1. Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN/THWN-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THWN-2, single conductors in raceway.
- E. Exposed Branch Circuits: Type THHN/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions:
1. All occupancies and power systems: Type THHN/THWN-2, single conductors in raceway.

- 2. Business occupancy, normal power system: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.
- 3. Hospital occupancy, normal power system: Type THHN/THWN-2, single conductors in raceway or Healthcare Facility Metal-clad cable, Type MC-HCF.
- G. [Metal-clad cable, Type MC] Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THWN-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless steel, wire-mesh, strain relief device at terminations to suit application.
- I. VFD Output Circuits: Type XHHW-2 in metal conduit.
- J. Isolated Power Circuits: Type XHHW-2 in metal conduit.

3.3 INSTALLATION, GENERAL

- 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 parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material.
 - 1. Use oxide inhibitor in each splice, termination, and tap for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inch of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
 - 2. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors feeding the following critical equipment and services for compliance with requirements:
 - a. Normal Power Service Entrance.
 - b. Emergency Power System.
 - 3. Perform each of the following visual and electrical tests:
 - a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - b. Test bolted connections for high resistance using one of the following:
 - 1) A low-resistance ohmmeter.
 - 2) Calibrated torque wrench.
 - 3) Thermographic survey.
 - c. Inspect compression-applied connectors for correct cable match and indentation.
 - d. Inspect for correct identification.
 - e. Inspect cable jacket and condition.
 - f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500 V(dc) for 300 V rated cable and 1000 V(dc) for 600 V rated cable for a one-minute duration.

- g. Continuity test on each conductor and cable.
 - h. Uniform resistance of parallel conductors.
- B. Cables will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Ground bonding common with lightning protection system.
 - 2. Foundation steel electrodes.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control reports.
- C. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 260010 "Supplemental Requirements for Electrical," include the following:
 - a. Plans showing as-built, dimensioned locations of system described in "Field Quality Control" Article, including the following:
 - 1) Ground rings.
 - 2) Grounding arrangements and connections for separately derived systems.
 - b. Instructions for periodic testing and inspection of grounding features at ground rings and grounding connections for separately derived systems based on NETA MTS.
 - 1) Tests must determine if ground-resistance or impedance values remain within specified maximums, and instructions must recommend corrective action if values do not.
 - 2) Include recommended testing intervals.

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 CONDUCTORS

- A. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B3.
 - 2. Stranded Conductors: ASTM B8.
 - 3. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inch wide and 1/16 inch thick.
- B. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inch in cross section, with 9/32 inch holes spaced 1-1/8 inch apart. Stand-off insulators for mounting must comply with UL 891 for use in switchboards, 600 V and must be Lexan or PVC, impulse tested at 5000 V.

2.3 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. Compression-Type Bus-Bar Connectors: 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. Conduit Hubs: Mechanical type, terminal with threaded hub.
- G. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- H. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- I. Straps: Solid copper, copper lugs. Rated for 600 A.
- J. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- K. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with zinc-plated bolts.
 - a. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector rated for direct burial.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install barecopper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 30 inch 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 inch minimum from wall, 6 inch 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 except at test wells and as otherwise indicated.
 - 3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors must be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Generator: Install grounding electrode(s) at the generator location. The electrode must be connected to the equipment grounding conductor and to the frame of the generator.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. 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.
- C. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from

panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.

3.5 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. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- D. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column at an exterior corner, extending around the perimeter of area or item indicated.
 - 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 inch from building's foundation.
- F. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least 20 ft. long. If reinforcing is

in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

- G. 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.

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

- 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
- 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
- 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal.
 - a. Measure ground resistance no fewer 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 grounding electrode location. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the size of the ground ring conductor and the depth, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Grounding system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

D. Report measured ground resistances that exceed the following values:

- 1. Substations and Pad-Mounted Equipment: 5 ohms.

- E. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Support, anchorage, and attachment components.
2. Fabricated metal equipment support assemblies.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32 inch diameter holes at a maximum of 8 inch on center in at least one surface.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ABB, Electrification Business.
 - b. Allied Tube & Conduit; Atkore International.
 - c. CADDY; brand of nVent Electrical plc.
 - d. Cooper B-line; brand of Eaton, Electrical Sector.
 - e. Flex-Strut Inc.
 - f. G-Strut.
 - g. Gripple Inc.
 - h. Haydon Corporation.
 - i. MIRO Industries.
 - j. Metal Ties Innovation.
 - k. Rocket Rack; Robroy Industries.
 - l. Unistrut; Atkore International.
 - m. Wesanco, Inc.
2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
3. Material for Channel, Fittings, and Accessories: Galvanized steel Plain steel.
4. Channel Width: Selected for applicable load criteria.
5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

6. In MRI rooms, nonferrous slotted support systems shall be used in lieu of steel. All accessories, including but not limited to hangers, connectors, screws, and bolts shall be nonferrous.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
 - C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs must have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body must be made of malleable iron.
 - D. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.
 - E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Cooper B-line; brand of Eaton, Electrical Sector.
 - 2) Empire Industries, Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
 5. Toggle Bolts: All steel springhead type.
 6. Hanger Rods: Threaded steel or Cable Hanger Style Supports.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 SELECTION

- A. Comply with the following standards for selection and installation of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 - 1. NECA NEIS 101
 - 2. NECA NEIS 102.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."
- D. Provide vibration and seismic controls with hangers and supports in accordance with requirements specified in "Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- E. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and ERMC as required by NFPA 70. Minimum rod size must be 1/4 inch in diameter or a suitable cable hanger style support with equal or greater strength.
- F. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted, or other as allowed in Part 2, support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 INSTALLATION OF SUPPORTS

- A. Comply with NECA NEIS 101 for installation requirements except as specified in this article.
- B. Raceway Support Methods: In addition to methods described in NECA NEIS 1, EMT, IMC, and ERMC may be supported by openings through structure members, in accordance with NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination must be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Existing Concrete: Expansion anchor fasteners.

4. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 5. To Light Steel: Sheet metal screws.
 6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated, but not less than 4 inch larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use concrete materials, reinforcement, and placement requirements as specified in Section 033000 "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base as follows:
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

END OF SECTION 260529

SECTION 260533 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EMT raceways and elbows.
2. Type EPEC raceways and fittings.
3. Type ERMC raceways, elbows, couplings, and nipples.
4. Type FMC raceways.
5. Type IMC raceways.
6. Type LFMC raceways.
7. Type PVC raceways and fittings.
8. Type RTRC-BG raceways and fittings.
9. Fittings for conduit, tubing, and cable.
10. Threaded metal joint compound.
11. Solvent cements.
12. Surface metal raceways and fittings.
13. Metallic outlet boxes, device boxes, rings, and covers.
14. Termination boxes.
15. Cabinets, cutout boxes, junction boxes, pull boxes, and miscellaneous enclosures.
16. Cover plates for device boxes.
17. Hoods for outlet boxes.

PART 2 - PRODUCTS

2.1 TYPE EMT RACEWAYS AND ELBOWS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 797 or UL 797A (as applicable) and UL Category Control Number FJMX.

B. Aluminum Electrical Metal Tubing (EMT-A) and Elbows:

1. Material: Aluminum.
2. Options:
 - a. Minimum Trade Size:
 - 1) In-Wall: Metric designator 16 (trade size 1/2).
 - 2) All Other Locations: Metric designator 21 (trade size 3/4).

C. Steel Electrical Metal Tubing (EMT-S) and Elbows:

1. Material: Steel.
2. Options:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc with organic top coating.
 - c. Minimum Trade Size:
 - 1) In-Wall: Metric designator 16 (trade size 1/2).
 - 2) All Other Locations: Metric designator 21 (trade size 3/4).

2.2 TYPE EPEC RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 651A and UL Category Control Number EAZX.

B. Electrical HDPE Underground Conduit (EPEC-40, EPEC-80, EPEC-A, EPEC-B):

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. Blue Diamond Industries, LLC.
 - b. JM Eagle.
 - c. Petroflex North America.
 - d. Prysmian Cables and Systems; Prysmian Group North America.
 - e. Southwire Company, LLC.
2. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.3 TYPE ERM C RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 6 and UL Category Control Number DYIX.

B. Galvanized-Steel Electrical Rigid Metal Conduit (ERM C-S-G), Elbows, Couplings, and Nipples:

1. Exterior Coating: Zinc.
2. Options:
 - a. Interior Coating: Zinc with organic top coating.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.4 TYPE FMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1 and UL Category Control Number DXUZ.

B. Steel Flexible Metal Conduit (FMC-S):

1. Material: Steel.
2. Options:
 - a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

C. Aluminum Flexible Metal Conduit (FMC-A):

1. Material: Aluminum.
2. Options:
 - a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

2.5 TYPE IMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1242 and UL Category Control Number DYBY.

B. Steel Electrical Intermediate Metal Conduit (IMC):

1. Options:
 - a. Exterior Coating: Zinc.
 - b. Interior Coating: Zinc with organic top coating.
 - c. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.6 TYPE LFMC RACEWAYS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 360 and UL Category Control Number DXHR.

B. Steel Liquidtight Flexible Metal Conduit (LFMC-S):

1. Material: Steel.
2. Options:

- a. Minimum Trade Size: Metric designator 16 (trade size 1/2).

2.7 TYPE PVC RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 651 and UL CCN DZYR.

B. Rigid PVC Conduit (PVC-40, PVC-80) and 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. ABB, Electrification Business.
 - b. Calconduit; Atkore International.
 - c. JM Eagle.
 - d. NAPCO; Westlake Chemical Corp.
 - e. Opti-Com Manufacturing Network, Inc (OMNI).
 - f. Topaz Lighting & Electric.
- 2. Dimensional Specifications: Schedule 40 or Schedule 80.
- 3. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.8 TYPE RTRC-BG RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 2420 and UL CCN DZKT, for Type BG.

B. Low-Halogen, Belowground Reinforced Thermosetting Resin Conduit (RTRC-BG) and 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. Champion Fiberglass, Inc.
 - b. FRE Composites; Atkore International.
- 2. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.9 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Fittings for Type ERM, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:

1. General Characteristics: UL 514B and UL Category Control Number DWTT.
2. Options:
 - a. Material: Steel.
 - b. Coupling Method:
 - 1) Interior: Compression coupling
 - 2) Exterior: Raintight compression coupling with distinctive color gland nut.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

C. Fittings for Type EMT Raceways:

1. General Characteristics: UL 514B and UL Category Control Number FKAV.
2. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

D. Fittings for Type FMC Raceways:

1. General Characteristics: UL 514B and UL Category Control Number ILNR.

E. Fittings for Type LFMC Raceways:

1. General Characteristics: UL 514B and UL Category Control Number DXAS.

2.10 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 2419 and UL Category Control Number FOIZ.

2.11 SOLVENT CEMENTS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL Category Control Number DWTT.
3. Sustainability Characteristics:

2.12 SURFACE METAL RACEWAYS AND FITTINGS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 5 and UL Category Control Number RJBT.

B. Surface Metal Raceways and Fittings with Metal Covers:

1. Options:
 - a. Galvanized steel base with snap-on covers.
 - b. Manufacturer's standard enamel finish in color selected by Architect.
 - c. Wiring Channels: Per site specific medical equipment drawings. Multiple channels must be capable of housing a standard 20 to 30 A NEMA device flush within the raceway.

2.13 METALLIC OUTLET BOXES, DEVICE BOXES, RINGS, AND COVERS

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 514A and UL Category Control Number QCIT.

B. Metallic Outlet Boxes:

1. Description: Box having pryout openings, knockouts, threaded entries, or hubs in either the sides of the back, or both, for entrance of conduit, conduit or cable fittings, or cables, with provisions for mounting outlet box cover, but without provisions for mounting wiring device directly to box.
2. Options:
 - a. Material: Sheet steel.
 - b. Sheet Metal Depth: Minimum 2.8 inch.
 - c. Luminaire Outlet Boxes and Covers: Nonadjustable, listed and labeled for attachment of luminaire weighing up to 50 lb.
 - d. Paddle Fan Outlet Boxes and Covers: Nonadjustable, designed for attachment of paddle fan weighing up to 70 lb.

C. Metallic Conduit Bodies:

1. Description: Means for providing access to interior of conduit or tubing system through one or more removable covers at junction or terminal point. In the United States, conduit bodies are listed in accordance with outlet box requirements.

D. Metallic Extension Rings:

1. Description: Ring intended to extend sides of outlet box or device box to increase box depth, volume, or both.

2.14 TERMINATION BOXES

- A. Description: Enclosure for termination base consisting of lengths of bus bars, terminal strips, or terminal blocks with provision for wire connectors to accommodate incoming or outgoing conductors or both.

B. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics: UL 1773 and UL Category Control Number XCKT.

C. Termination Boxes and Termination Bases for Installation on Line Side of Service Equipment:

1. Additional Characteristics: Listed and labeled for installation on line side of service equipment.

D. Termination Boxes and Termination Bases for Installation on Load Side of Service Equipment:

1. Additional Characteristics: Listed and labeled for installation on load side of service equipment.

2.15 CABINETS, CUTOUT BOXES, JUNCTION BOXES, PULL BOXES, AND MISCELLANEOUS ENCLOSURES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. Non-Environmental Characteristics: UL 50.
 - b. Environmental Characteristics: UL 50E.

B. Indoor Sheet Metal Cabinets:

1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
2. Additional Characteristics: UL Category Control Number CYIV.

C. Indoor Sheet Metal Cutout Boxes:

1. Description: Enclosure that has swinging doors or covers secured directly to and telescoping with walls of enclosure.
2. Additional Characteristics: UL Category Control Number CYIV.

D. Indoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Additional Characteristics: UL Category Control Number BGUZ.

E. Indoor Sheet Metal Miscellaneous Enclosures:

1. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.

F. Outdoor Sheet Metal Cabinets:

1. Description: Enclosure provided with frame, mat, or trim in which swinging door or doors are or can be hung.
2. Additional Characteristics: UL Category Control Number CYIV.

G. Outdoor Sheet Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Additional Characteristics: UL Category Control Number BGUZ.

H. Outdoor Cast-Metal Junction and Pull Boxes:

1. Description: Box with a blank cover that serves the purpose of joining different runs of raceway or cable.
2. Additional Characteristics: UL Category Control Number BGUZ.

I. Outdoor Sheet Metal Miscellaneous Enclosures:

1. Additional Characteristics: UL 1773 and UL Category Control Number XCKT.

2.16 COVER PLATES FOR DEVICES BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. Reference Standards: UL 514D and UL Category Control Numbers QCIT and QCMZ.
 - b. Wallplate-Securing Screws: Metal with head color to match wallplate finish.

B. Metallic Cover Plates for Device Boxes:

1. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: Galvanized steel.

C. Nonmetallic Cover Plates for Device Boxes:

1. Options:
 - a. Damp and Wet Locations: Listed, labeled, and marked for location and use. Provide gaskets and accessories necessary for compliance with listing.
 - b. Wallplate Material: 0.060 inch thick high-impact thermoplastic (nylon) with smooth finish and color matching wiring device.

2.17 HOODS FOR OUTLET BOXES

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. Reference Standards:
 - 1) UL 514D and UL Category Control Numbers QCIT and QCMZ.
 - 2) Receptacle, hood, cover plate, gaskets, and seals comply with UL 498 Supplement SA when mated with box or enclosure complying with UL 514A, UL 514C, or UL 50E.
 - b. Mounts to box using fasteners different from wiring device.

B. Extra-Duty, While-in-Use Hoods for Outlet Boxes:

1. Additional Characteristics: Marked "Extra-Duty" in accordance with UL 514D.
2. Options:
 - a. Provides clear, weatherproof, "while-in-use" cover.
 - b. Manufacturer may combine nonmetallic device box with hood as extra-duty rated assembly.

PART 3 - EXECUTION

3.1 SELECTION OF RACEWAYS

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of raceways. Consult Architect for resolution of conflicting requirements.

B. Outdoors:

1. Exposed and Subject to Severe Physical Damage: ERM C.
2. Exposed and Subject to Physical Damage: IM C.
 - a. Locations less than 2.5 m (8 ft) above finished floor.
3. Exposed and Not Subject to Physical Damage: IM C.
4. Concealed Aboveground: EMT.
5. Direct Buried or Concrete Encased: Refer to Section 260543 "Underground Ducts and Raceways for Electrical Systems."
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.

C. Indoors:

1. Hazardous Classified Locations: ERM C.
2. Exposed and Subject to Severe Physical Damage: ERM C. Subject to severe physical damage includes the following locations:
 - a. Loading docks.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
3. Exposed and Subject to Physical Damage: IM C. Subject to physical damage includes the following locations:
 - a. Locations less than 2.5 m (8 ft) above finished floor.
 - b. Stub-ups to above suspended ceilings.
4. Exposed and Not Subject to Physical Damage: EMT.
5. Concealed in Ceilings and Interior Walls and Partitions: EMT.
6. Damp or Wet Locations: IM C.
7. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC.
8. Circuits Operating Above 60 Hz: EMT-A. Provide nonmetallic sleeve where aluminum raceways pass through concrete.

D. Raceway Fittings: Select fittings in accordance with NEMA FB 2.10 guidelines.

1. ERM C and IM C: Provide threaded type fittings unless otherwise indicated.

3.2 SELECTION OF BOXES AND ENCLOSURES

- A. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for selection of boxes and enclosures. Consult Architect for resolution of conflicting requirements.

B. Degree of Protection:

1. Outdoors:

- a. Type 3R unless otherwise indicated.
 - b. Locations Exposed to Hosedown: Type 4.
 - c. Locations Subject to Potential Flooding: Type 6P.
 - d. Locations Aboveground Where Mechanism Must Operate When Ice Covered: Type 3S.
 - e. Locations in-Ground or Exposed to Corrosive Agents: Type 3RX.
 - f. Locations in-Ground or Exposed to Corrosive Agents Where Mechanism Must Operate When Ice Covered: Type 3SX.
2. Indoors:
- a. Type 1 unless otherwise indicated.
 - b. Damp or Dusty Locations: Type 2.
 - c. Surface Mounted in Kitchens and Other Locations Exposed to Oil or Coolants: Type 12.
 - d. Locations Exposed to Hosedown: Type 4.

C. Exposed Boxes Installed Less Than 2.5 m (8 ft) Above Floor:

- 1. Provide cast-metal boxes.
- 2. Provide exposed cover. Flat covers with angled mounting slots or knockouts are prohibited.

3.3 INSTALLATION OF RACEWAYS

A. Installation Standards:

- 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' written instructions, comply with NFPA 70 for installation of raceways. Consult Architect for resolution of conflicting requirements.
- 2. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- 3. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- 4. Comply with NECA NEIS 101 for installation of steel raceways.
- 5. Comply with NECA NEIS 102 for installation of aluminum raceways.
- 6. Comply with NECA NEIS 111 for installation of nonmetallic raceways.
- 7. Install raceways square to the enclosure and terminate at enclosures without hubs with locknuts on both sides of enclosure wall. Install locknuts hand tight, plus one-quarter turn more.
- 8. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to metric designator 35 (trade size 1-1/4) and insulated throat metal bushings on metric designator 41 (trade size 1-1/2) and larger conduits terminated with locknuts..
- 9. Raceway Terminations at Locations Subject to Moisture or Vibration:
 - a. Provide insulating bushings to protect conductors, including conductors smaller than No. 4 AWG..

B. General Requirements for Installation of Raceways:

1. Complete raceway installation before starting conductor installation.
2. Provide stub-ups through floors with coupling threaded inside for plugs, set flush with finished floor. Plug coupling until conduit is extended above floor to final destination or a minimum of 2 ft above finished floor.
3. Install no more than equivalent of four 90-degree bends in conduit run. Support within 12 inch of changes in direction.
4. Make bends in raceway using large-radius preformed ells except for parallel bends. Field bending must be in accordance with NFPA 70 minimum radii requirements. Provide only equipment specifically designed for material and size involved.
5. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
6. Support conduit within 12 inch of enclosures to which attached.
7. Install raceway sealing fittings at accessible locations in accordance with NFPA 70 and fill them with listed sealing compound. For concealed raceways, install fitting in flush steel box with blank cover plate having finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings in accordance with NFPA 70.
8. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal interior of raceways at the following points:
 - a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - b. Where an underground service raceway enters a building or structure.
 - c. Conduit extending from interior to exterior of building.
 - d. Conduit extending into pressurized duct and equipment.
 - e. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
 - f. Where otherwise required by NFPA 70.
9. Do not install conduits within 2 inch of the bottom side of a metal deck roof.
10. Keep raceways at least 6 inch away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
11. Cut conduit perpendicular to the length. For conduits metric designator 53 (trade size 2) and larger, use roll cutter or a guide to make cut straight and perpendicular to the length. Ream inside of conduit to remove burrs.
12. Install pull wires in empty raceways. Provide polypropylene or monofilament plastic line with not less than 200 lb tensile strength. Leave at least 12 inch of slack at both ends of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

C. Requirements for Installation of Specific Raceway Types:

1. Types EMT-A, ERMC-A, and FMC-A:
 - a. Do not install aluminum raceways or fittings in contact with concrete or earth.
2. Types ERMC and IMC:
 - a. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound that maintains electrical conductivity to

threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

3. Types FMC and LFMC:

- a. Comply with NEMA RV 3. Provide a maximum of 72 inch of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

4. Types PVC and EPEC:

- a. Do not install Type PVC or Type EPEC conduit where ambient temperature exceeds 122 deg F. Conductor ratings must be limited to 75 deg C except where installed in a trench outside buildings with concrete encasement, where 90 deg C conductors are permitted.
- b. Comply with manufacturer's written instructions for solvent welding and fittings.

D. Stub-ups to Above Recessed Ceilings:

1. Provide EMT, IMC, or ERM for raceways.
2. Provide a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

E. Raceway Fittings: Install fittings in accordance with NEMA FB 2.10 guidelines.

1. EMT: Provide compression, steel fittings. Comply with NEMA FB 2.10.
2. Flexible Conduit: Provide only fittings listed for use with flexible conduit type. Comply with NEMA FB 2.20.

F. Expansion-Joint Fittings:

1. Install in runs of aboveground PVC that are located where environmental temperature change may exceed 30 deg F and that have straight-run length that exceeds 25 ft. Install in runs of aboveground ERM and EMT conduit that are located where environmental temperature change may exceed 100 deg F and that have straight-run length that exceeds 100 ft.
2. Install type and quantity of fittings that accommodate temperature change listed for the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at locations where conduits cross building or structure expansion joints.

5. Install expansion-joint fitting with position, mounting, and piston setting selected in accordance with manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

G. Raceways Penetrating Rooms or Walls with Acoustical Requirements:

1. Seal raceway openings on both sides of rooms or walls with acoustically rated putty or firestopping.

3.4 INSTALLATION OF SURFACE RACEWAYS

- A. Install surface raceways only where indicated on Medical Equipment Site Specific Drawings.
- B. Install surface raceway with a minimum 2 inch radius control at bend points.
- C. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch (mm) and with no less than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's written instructions. Tape and glue are unacceptable support methods.

3.5 INSTALLATION OF BOXES AND ENCLOSURES

- A. Provide boxes in wiring and raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures.
- B. Refer to Electrical Legend for box mounting heights.
- C. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- D. Locate boxes so that cover or plate will not span different building finishes.
- E. Support boxes in recessed ceilings independent of ceiling tiles and ceiling grid.
- F. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for purpose.
- G. Fasten junction and pull boxes to, or support from, building structure. Do not support boxes by conduits.
- H. Do not install aluminum boxes, enclosures, or fittings in contact with concrete or earth.
- I. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to ensure a continuous ground path.
- J. Boxes and Enclosures in Areas or Walls with Acoustical Requirements:
 1. Seal openings and knockouts in back and sides of boxes and enclosures with acoustically rated putty.
 2. Provide gaskets for wallplates and covers.

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

3.8 CLEANING

- A. Boxes: Remove construction dust and debris from device boxes, outlet boxes, and floor-mounted enclosures before installing wallplates, covers, and hoods.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Type EPEC raceways and fittings.
2. Type ERMCS raceways, elbows, couplings, and nipples.
3. Type PVC raceways and fittings.
4. Type RTRC-BG raceways and fittings.
5. Fittings for conduit, tubing, and cable.
6. Threaded metal joint compound.
7. Solvent cements.
8. Duct accessories.
9. Handholes and boxes for exterior underground wiring.
10. Duct sealing.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

B. Preinstallation Coordination Meeting(s): For underground ducts and raceways. Conduct meeting(s) at Project site before beginning trenching.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect and Construction Manager of scheduled meeting dates.

1.3 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Electric Utility Duct Banks and Structures:
 - a. Include plans, elevations, sections, and details, including attachments to other Work.
 - b. Indicate locations of private property boundaries and utility easements.
 - c. Include information required for approval by electric utility and for obtaining public space utility work permits.
2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:

- a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
- b. Include duct entry provisions, including locations and duct sizes, and methods and materials for waterproofing duct entry locations.
- c. Include cover design.
- d. Include grounding details.
- e. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and other accessories.

1.4 REGULATORY AGENCY APPROVALS

- A. Shop Drawing submittals for electric utility duct banks and structures must be signed and sealed by qualified electrical professional engineer responsible for their preparation. Obtain approval by electric utility prior to submitting for action by Architect.
- B. Submit Shop Drawings for electric utility duct banks and structures for action by Architect prior to submitting for approval by electric utility.

PART 2 - PRODUCTS

2.1 TYPE EPEC RACEWAYS AND FITTINGS

- A. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 - 2. General Characteristics: UL 651A and UL CCN EAZX.
- B. Electrical HDPE Underground Conduit (EPEC-40, EPEC-80, EPEC-A, EPEC-B):
 - 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. Blue Diamond Industries, LLC.
 - b. JM Eagle.
 - c. Petroflex North America.
 - d. Prysmian Cables and Systems; Prysmian Group North America.
 - e. Southwire Company, LLC.
 - 2. Dimensional Specifications: Schedule 40, Schedule 80, Type A, or Type B.
 - 3. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.2 TYPE ERM-C-S RACEWAYS, ELBOWS, COUPLINGS, AND NIPPLES

- A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL 6 and UL CCN DYIX.
- B. Galvanized-Steel Electrical Rigid Metal Conduit (ERMC-S-G), Elbows, Couplings, and Nipples:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Allied Tube & Conduit; Atkore International.
 - b. Calconduit; Atkore International.
 - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - d. Killark; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - e. Patriot Aluminum Products, LLC.
 - f. Republic Conduit; Nucor Corporation, Nucor Tubular Products.
 - g. Topaz Lighting & Electric.
 - h. Western Tube; Zekelman Industries.
 - i. Wheatland Tube; Zekelman Industries.
 2. Exterior Coating: Zinc.
 3. Options:
 - a. Interior Coating: Zinc with organic top coating.
 - b. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.3 TYPE PVC RACEWAYS AND FITTINGS

- A. Performance Criteria:
1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL 651 and UL CCN DZYR.
- B. Rigid PVC Conduit (PVC-40, PVC-80) and 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. ABB, Electrification Business.
 - b. Calconduit; Atkore International.
 - c. JM Eagle.
 - d. NAPCO; Westlake Chemical Corp.
 - e. Opti-Com Manufacturing Network, Inc (OMNI).
 - f. Topaz Lighting & Electric.
 2. Dimensional Specifications: Schedule 40 or Schedule 80.
 3. Options:

- a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.4 TYPE RTRC-BG RACEWAYS AND FITTINGS

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
- 2. General Characteristics: UL 2420 and UL CCN DZKT, for Type BG.

B. Low-Halogen, Belowground Reinforced Thermosetting Resin Conduit (RTRC-BG) and 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. Champion Fiberglass, Inc.
 - b. FRE Composites; Atkore International.
- 2. Options:
 - a. Minimum Trade Size: Metric designator 21 (trade size 3/4).

2.5 FITTINGS FOR CONDUIT, TUBING, AND CABLE

A. Performance Criteria:

- 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.

B. Metallic Fittings for Type ERM, Type IMC, Type PVC, Type EPEC, and Type RTRC Raceways:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ABB, Electrification Business.
 - b. Appleton; Emerson Electric Co., Automation Solutions.
 - c. Crouse-Hinds; brand of Eaton, Electrical Sector.
 - d. Konkore Fittings; Atkore International.
 - e. O-Z/Gedney; brand of Emerson Electric Co., Automation Solutions, Appleton Group.
 - f. Penn Aluminum Conduit & EMT; Penn Aluminum International LLC; Berkshire Hathaway.
 - g. Raco Taymac Bell; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - h. Southwire Company, LLC.
 - i. Topaz Lighting & Electric.

2. General Characteristics: UL 514B and UL CCN DWTT.
3. Options:
 - a. Material: Steel.
 - b. Coupling Method: Compression coupling.
 - c. Conduit Fittings for Hazardous (Classified) Locations: UL 1203.
 - d. Expansion and Deflection Fittings: UL 651 with flexible external bonding jumper.

2.6 ELECTRICALLY CONDUCTIVE CORROSION-RESISTANT COMPOUNDS FOR THREADED CONDUIT

- A. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: UL Subject 2419 and UL CCN FOIZ.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. ABB, Electrification Business.

2.7 SOLVENT CEMENTS

- A. Performance Criteria:
 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
 2. General Characteristics: As recommended by conduit manufacturer in accordance with UL 514B and UL CCN DWTT.

2.8 DUCT ACCESSORIES

- A. Duct Spacers: Factory-fabricated, rigid, PVC interlocking spacers; sized for type and size of duct with which used, and selected to provide minimum duct spacing indicated while supporting duct during concreting or backfilling.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. ABB, Electrification Business.
 - b. Allied Tube & Conduit; Atkore International.
 - c. Cantex Inc.
 - d. IPEX USA LLC.
 - e. PenCell Plastics; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - f. Underground Devices, Inc.
- B. Underground-Line Warning Tape: In accordance with Section 260553 "Identification for Electrical Systems."

2.9 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Performance Criteria:

1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 and marked for intended location and use.
2. General Characteristics:
 - a. ASTM C858 for design and manufacturing processes.
 - b. SCTE 77.

B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover:

1. Description: Molded of sand, concrete, and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or combination.
2. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Armorcast Products Company; brand of Hubbell Utility Solutions; Hubbell Incorporated.
 - b. MacLean Highline.
 - c. NewBasis.
 - d. Oldcastle Infrastructure Inc.; CRH Americas.
 - e. Quazite; brand of Hubbell Utility Solutions; Hubbell Incorporated.
3. Configuration: Units must be designed for flush burial and have open bottom unless otherwise indicated.
4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and installed location.
 - a. Cover Finish: Nonskid finish must have minimum coefficient of friction of 0.50.
 - b. Cover Legend: Molded lettering, as appropriate for service:
 - 1) "ELECTRIC".
 - 2) "FIBER".
5. Conduit Entrance Provisions: Conduit-terminating fittings must mate with entering ducts for secure, fixed installation in enclosure wall.
6. Handholes 12 inch wide by 24 inch long (300 mm wide by 600 mm long) and larger must have factory-installed inserts for cable racks and pulling-in irons.
7. Options:
 - a. Color: Gray.

2.10 DUCT SEALING

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

1. [ABB, Electrification Business.](#)
2. American Polywater Corporation.
3. [CommScope, Inc.](#)
4. [Gardner Bender.](#)
5. [Ideal Industries, Inc.](#)
6. [NSi Industries LLC.](#)
7. [TE Connectivity Ltd.](#)

- B. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F. Compound must be capable of withstanding temperature of 300 deg F without slump and adhering to clean surfaces of plastic ducts, metallic conduit, conduit and duct coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals. Duct sealing compound must be removable without damaging ducts or cables.
- C. Inflatable Duct-Sealing System: Wraparound inflatable bladder that seals ducts that are empty or containing conductors against air and water infiltration. System is suitable for use in steel, plastic, or concrete ducts and penetrations.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of duct, duct bank, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in field. Notify Architect if there is conflict between areas of excavation and existing structures or archaeological sites to remain.
- B. Coordinate elevations of duct and duct-bank entrances into handholes and boxes with final locations and profiles of duct and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct and duct bank will drain to handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain in accordance with Section 311000 "Site Clearing." Remove and stockpile topsoil for reapplication in accordance with Section 311000 "Site Clearing."

3.2 SELECTION OF UNDERGROUND DUCTS

- A. Duct for Electrical Feeders: PVC-80 or EPEC-80, direct buried unless otherwise indicated.
- B. Duct for Electrical Branch Circuits: PVC-40 or EPEC-40, direct buried unless otherwise indicated.
- C. Bored Underground Duct: EPEC-40 or EPEC-80 unless otherwise indicated.
- D. Underground Ducts Crossing Roadways: PVC-40, encased in reinforced concrete.

- E. Stub-ups: Concrete encased, PVC-80 or PVC-40, based on duct.

3.3 EARTHWORK

- A. Excavation and Backfill: Comply with Section 312000 "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restoration: Restore area after construction vehicle traffic in immediate area is complete.
- C. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- D. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Section 329200 "Turf and Grasses" and Section 329300 "Plants."

3.4 INSTALLATION OF DUCTS AND DUCT BANKS

- A. Reference Standards:
 - 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with NEMA TCB 2 for installation of underground ducts and duct banks.
 - 2. Consult Architect for resolution of conflicting requirements.
- B. Special Techniques:
 - 1. Steel raceway, bends, and fittings in single duct run or duct bank must be of same type.
 - 2. Slope: Pitch duct minimum slope of 1:300 down toward handholes and away from buildings and equipment. Slope duct from high point between two handholes to drain in both directions.
 - 3. Curves and Bends:
 - a. Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with minimum radius of 48 inch, both horizontally and vertically, at other locations unless otherwise indicated.
 - b. Duct must have maximum of 270 degrees of bends between pull points.
 - 4. Joints: Use solvent-cemented joints in nonmetallic duct and fittings and make watertight in accordance with manufacturer's published instructions. Stagger couplings so those of adjacent duct do not lie in same plane. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.
 - 5. Building Wall Penetrations: Make transition from underground duct to steel raceway at least 10 ft outside building wall, without reducing duct line slope away from building and without forming trap in line. Use fittings manufactured for transition to steel raceway type installed.
 - 6. Install manufactured steel raceway elbows for stub-ups at poles unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.

- a. Couple steel elbows to ducts with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete for minimum of 12 inch on each side of coupling.
7. Sealing: Provide temporary closure at terminations of duct with pulled cables. Seal spare duct at terminations. Use sealing compound and plugs to withstand at least 15 psig hydrostatic pressure.
8. Pulling Cord: Install 200 lbf test nylon cord in empty ducts.
9. Concrete-Encased Ducts and Duct Bank:
 - a. Excavate trench bottom to provide firm and uniform support for duct. Prepare trench bottoms as specified in Section 312000 "Earth Moving" for pipes 6 inch or less in nominal diameter.
 - b. Support duct on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - c. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to duct to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - d. Minimum Space between Ducts: 3 inch between edge of duct and exterior envelope wall, 2 inch between ducts for like services, and 4 inch between power and communications ducts.
 - e. Elbows:
 - 1) Use manufactured duct elbows for stub-ups and at changes of direction in duct unless otherwise indicated. Extend encasement throughout length of elbow.
 - f. Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of equipment base.
 - 1) Stub-ups must be minimum 4 inches above finished floor and minimum 3 inches from conduit side to edge of slab.
 - g. Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - 1) Stub-ups must be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of slab.
 - h. Reinforcement: Reinforce concrete-encased duct where crossing disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 - i. Concrete Cover: Install minimum of 3 inch of concrete cover between edge of duct to exterior envelope wall, 2 inch between duct of like services, and 4 inch between power and communications ducts.
 - j. Place minimum 6 inch of engineered fill above concrete encasement of duct.

- k. Concreting Sequence: Pour each run of envelope between terminations in one continuous operation.
 - 1) Start at one end and finish at other, allowing for expansion and contraction of duct as its temperature changes during and after pour. Use expansion fittings installed in accordance with manufacturer's published instructions, or use other specific measures to prevent expansion-contraction damage.
 - 2) If more than one pour is necessary, terminate each pour in vertical plane and install 3/4 inch reinforcing-rod dowels extending minimum of 18 inch into concrete on both sides of joint near corners of envelope.
 - l. Pouring Concrete: Comply with requirements in "Concrete Placement" Article in Section 033000 "Cast-in-Place Concrete." Place concrete carefully during pours to prevent voids under and between duct and at exterior surface of envelope. Do not allow heavy mass of concrete to fall directly onto ducts. Allow concrete to flow around duct and rise up in middle, uniformly filling open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-installation application.
10. Direct-Buried Duct and Duct Bank:
- a. Excavate trench bottom to provide firm and uniform support for duct. Comply with requirements in Section 312000 "Earth Moving" for preparation of trench bottoms for pipes less than 6 inch in nominal diameter.
 - b. Set elevation of top of duct bank below frost line.
 - c. Place minimum 3 inch of sand as bed for duct. Place sand to minimum of 6 inch above top level of duct.
 - d. Support ducts on duct spacers coordinated with duct size, duct spacing, and outdoor temperature.
 - e. Spacer Installation: Place spacers close enough to prevent sagging and deforming of duct, with not less than four spacers per 20 ft of duct. Place spacers within 24 inch of duct ends. Stagger spacers approximately 6 inch between tiers. Secure spacers to earth and to ducts to prevent floating during concreting. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 - f. Install duct with minimum of 3 inch between ducts for like services and 6 inch between power and communications duct.
 - g. Install manufactured steel elbows for stub-ups, at building entrances, and at changes of direction in duct.
 - 1) Couple RNC duct to steel raceway with adapters designed for this purpose, and encase coupling with minimum 3 inch of concrete.
 - 2) Stub-ups to Outdoor Equipment: Extend concrete-encased steel raceway horizontally minimum of 60 inch from edge of base. Install insulated grounding bushings on terminations at equipment.
 - a) Stub-ups must be minimum 4 inches above finished base and minimum 3 inches from conduit side to edge of base.

- 3) Stub-ups to Indoor Equipment: Extend concrete-encased steel raceway horizontally on exterior of wall minimum of 60 inches from edge of wall. Install insulated grounding bushings on terminations at equipment.
 - a) Stub-ups through interior floors must be minimum 4 inches above finished floor and no less than 3 inches from conduit side to edge of equipment pad or floor slab.
- h. After installing first tier of duct, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand place backfill to 4 inch over duct and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction. Comply with requirements in Section 312000 "Earth Moving" for installation of backfill materials.
11. Underground-Line Warning Tape: Bury conducting underground line specified in Section 260553 "Identification for Electrical Systems" no less than 12 inches above concrete-encased duct and duct banks and approximately 12 inches below grade. Align tape parallel to and within 3 inch of centerline of duct bank. Provide additional warning tape for each 12 inch increment of duct-bank width over nominal 18 inch. Space additional tapes 12 inch apart, horizontally across width of ducts.
12. Ground ducts and duct banks in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.5 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Special Techniques:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting duct, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of duct, and seal joint between box and extension as recommended by manufacturer.
2. Unless otherwise indicated, support units on level bed of crushed stone or gravel, graded from 1/2 inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes 1 inch above finished grade.
4. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
5. Field cut openings for duct in accordance with enclosure manufacturer's published instructions. Cut wall of enclosure with tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
6. Ground handholes and boxes in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Demonstrate capability and compliance with requirements on completion of installation of underground duct, duct bank, and utility structures.
2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide minimum 12 inch long mandrel equal to duct size minus 1/4 inch. If obstructions are indicated, remove obstructions and retest.
3. Test handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."

B. Nonconforming Work:

1. Underground ducts, raceways, and structures will be considered defective if they do not pass tests and inspections.
2. Correct deficiencies and retest as specified above to demonstrate compliance.

C. Assemble and submit test and inspection reports.

3.7 CLEANING

- #### A.
- Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of duct until duct cleaner indicates that duct is clear of dirt and debris. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Round sleeves.
2. Rectangular sleeves.
3. Sleeve seal systems.
4. Grout.
5. Pourable sealants.
6. Foam sealants.

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

A. Wall Sleeves, Steel:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Advance Products & Systems, LLC.
 - b. CCI Piping Systems.
 - c. Flexicraft Industries.
 - d. GPT; a division of EnPRO Industries.
 - e. Specified Technologies Inc.
2. Description: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

B. Wall Sleeves, Cast Iron:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. American Cast Iron Pipe Company.
 - b. Flexicraft Industries.
 - c. McWane Ductile.
2. Description: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

C. Sheet Metal Sleeves, Galvanized Steel, Round:

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. Benefast.
 - b. Specified Technologies Inc.
2. Description: Galvanized-steel sheet; thickness not less than 0.0239 inch; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

2.2 RECTANGULAR SLEEVES

A. Sheet Metal Sleeves, Galvanized Steel, Rectangular:

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. Abesco Fire LLC.
 - b. Specified Technologies Inc.
 - c. Wiremold; Legrand North America, LLC.
2. Description:
 - a. Material: Galvanized sheet steel.
 - b. Minimum Metal Thickness:
 - 1) For sleeve cross-section rectangle perimeter less than 50 inch and with no side larger than 16 inch, thickness must be 0.052 inch.
 - 2) For sleeve cross-section rectangle perimeter not less than 50 inch or with one or more sides larger than 16 inch, thickness must be 0.138 inch.

2.3 SLEEVE SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Advance Products & Systems, LLC.
 2. American Polywater Corporation.
 3. BWM Company.
 4. CALPICO, Inc.
 5. Flexicraft Industries.
 6. GPT; a division of EnPRO Industries.
 7. Metraflex Company (The).
 8. Proco Products, Inc.
 9. Roxtec Inc.

- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable or between raceway and cable.
 - 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 GROUT

- 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. Specified Technologies Inc.
 - 2. W. R. Meadows, Inc.
- B. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
 - 1. Standard: ASTM C1107/C1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
 - 2. Design Mix: 5000 psi, 28-day compressive strength.
 - 3. Packaging: Premixed and factory packaged.

2.5 FOAM SEALANTS

- 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. Innovative Chemical Products (Building Solutions Group).
 - 2. The Dow Chemical Company.
- B. Description: Multicomponent, liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam. Foam expansion must not damage cables or crack penetrated structure.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:

- a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide 1/4 inch annular clear space between sleeve and raceway or cable, unless sleeve seal system is to be installed or seismic criteria require different clearance.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inch above finished floor level. Install sleeves during erection of floors.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for wall assemblies.
- C. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- D. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seal systems. Size sleeves to allow for 1 inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- E. Underground, Exterior-Wall and Floor Penetrations:
1. Install cast-iron pipe sleeves with integral waterstops. Size sleeves to allow for 1 inch annular clear space between raceway or cable and sleeve for installing sleeve seal system. Install sleeve during construction of floor or wall.
- 3.2 INSTALLATION OF RECTANGULAR SLEEVES AND SLEEVE SEALS
- A. Install sleeves in existing walls without compromising structural integrity of walls. Do not cut structural elements without reinforcing the wall to maintain the designed weight bearing and wall stiffness.
 - B. Install conduits and cable with no crossings within the sleeve.
 - C. Fill opening around conduits and cables with expanding foam without leaving voids.
 - D. Provide metal sheet covering at both wall surfaces and finish to match surrounding surfaces. Metal sheet must be same material as sleeve.

3.3 INSTALLATION OF SLEEVE SEAL SYSTEMS

- A. Install sleeve seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

END OF SECTION 260544

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Restraints - rigid type.
3. Restraints - cable type.
4. Restraint accessories.
5. Post-Installed concrete anchors.
6. Concrete inserts.

1.2 SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load capacity for each seismic-restraint device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
3. Annotate types and sizes of seismic restraints and accessories, complete with listing markings or report numbers and load rating in tension and compression as evaluated by an agency acceptable to authorities having jurisdiction.
4. Annotate to indicate application of each product submitted and compliance with requirements.

B. Delegated Design Submittal for Each Seismic-Restraint Device: Signed and sealed by qualified structural professional engineer.

1. For each seismic-restraint device, including restraint - rigid and cable type, restraint accessory, and concrete anchor and insert that is required by this Section or is indicated on Drawings, submit the following:
 - a. Seismic Restraints: Select seismic restraints complying with performance requirements, design criteria, and analysis data.
 - b. Post-Installed Concrete Anchors and Inserts: Include calculations showing anticipated seismic loads. Include certification that device is approved by an NRTL for seismic reinforcement use.
 - c. Seismic Design Calculations: Submit input data and loading calculations prepared under "Seismic Design Calculations" Paragraph in "Performance Requirements" Article.
2. Seismic-Restraint Detail Drawings: Signed and sealed by qualified structural professional engineer.

- a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
- b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage qualified structural professional engineer to design seismic control system.
- B. Consequential Damage: Provide additional seismic restraints for suspended components or anchorage of floor-, roof-, or wall-mounted components so that failure of a non-essential or essential component will not cause failure of any other essential building component.
- C. Fire/Smoke Resistance: Seismic-restraint devices that are not constructed of ferrous metals must have a maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL in accordance with ASTM E84 or UL 723, and be so labeled.
- D. Component Supports:
 - 1. Load ratings, features, and applications of reinforcement components must be based on testing standards of a nationally recognized testing agency.

2.2 ELASTOMERIC ISOLATION PADS

- A. Elastomeric Isolation Pads:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. [Ace Mountings Co., Inc.](#)
 - b. [CADDY; brand of nVent Electrical plc.](#)
 - c. [California Dynamics Corporation.](#)
 - d. [Isolation Technology, Inc.](#)
 - e. [Kinetics Noise Control, Inc.](#)
 - f. [Korfund.](#)
 - g. [Mason Industries, Inc.](#)
 - h. [NOVIA; a division of Carpenter & Paterson.](#)
 - i. [VMC GROUP.](#)
 - j. [Vibration Eliminator Co., Inc.](#)
 - k. [Vibration Isolation.](#)
 - l. [Vibration Management Corp.](#)

2. Fabrication: Single or multiple layers of sufficient durometer stiffness for uniform loading over pad area.
3. Size: Factory cut to match requirements of supported equipment.
4. Pad Material: Oil and water resistant with elastomeric properties. Neoprene rubber, silicone rubber, or other elastomeric material.
5. Surface Pattern: Smooth, ribbed, or waffle pattern.

2.3 RESTRAINTS - RIGID TYPE

- 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. CADDY; brand of nVent Electrical plc.
 2. California Dynamics Corporation.
 3. Cooper B-line; brand of Eaton, Electrical Sector.
 4. Hilti, Inc.
 5. Isolation Technology, Inc.
 6. TOLCO Incorporated.
 7. Unistrut; Atkore International.
 8. VMC GROUP.
- B. Description: Shop- or field-fabricated bracing assembly made of ANSI/AISI S110-07-S1 slotted steel channels, ANSI/ASTM A53/A53M steel pipe, or other rigid steel brace member. Includes accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.4 RESTRAINTS - CABLE TYPE

- 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. CADDY; brand of nVent Electrical plc.
 2. Cooper B-line; brand of Eaton, Electrical Sector.
 3. Gripple Inc.
 4. Loos & Co. Inc.
 5. VMC GROUP.
- B. Seismic-Restraint Cables: ASTM A1023/A1023M galvanized or ASTM A603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for seismic-restraining cable service; with fittings attached by means of poured socket, swaged socket, or mechanical (Flemish eye) loop.
- C. Restraint cable assembly and cable fittings must comply with ASCE/SEI 19. Cable fittings and complete cable assembly must maintain the minimum cable breaking force. U-shaped cable clips and wedge-type end fittings do not comply and are unacceptable.

2.5 RESTRAINT ACCESSORIES

- 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. CADDY; brand of nVent Electrical plc.
 2. Cooper B-line; brand of Eaton, Electrical Sector.
 3. Hilti, Inc.
 4. Loos & Co. Inc.
 5. Mason Industries, Inc.
 6. TOLCO Incorporated.
 7. Unistrut; Atkore International.
- B. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Non-metallic stiffeners are unacceptable.
- C. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to restraint cables.
- D. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- E. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- F. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.6 POST-INSTALLED CONCRETE ANCHORS

- A. Mechanical Anchor Bolts:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Unistrut; Atkore International.
 2. Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength for anchor and as tested according to ASTM E488/E488M.
- B. Adhesive Anchor Bolts:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper B-line; brand of Eaton, Electrical Sector.
 - b. Hilti, Inc.
 - c. Mason Industries, Inc.
 - d. Powers Fasteners.
 - e. Unistrut; Atkore International.
 2. Drilled-in and capsule anchor system containing PVC or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E488/E488M.
- C. Provide post-installed concrete anchors that have been prequalified for use in seismic and wind-load applications.
1. Prequalify post-installed anchors in concrete in accordance with ACI 355.2 or other approved qualification testing procedures.
 2. Prequalify post-installed anchors in masonry in accordance with approved qualification procedures.
- D. Expansion-type anchor bolts are not permitted for equipment in excess of 10 hp that is not vibration isolated.
1. Undercut expansion anchors are permitted.

2.7 CONCRETE INSERTS

- 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. Cooper B-line; brand of Eaton, Electrical Sector.
 2. Hilti, Inc.
 3. Mason Industries, Inc.
 4. Powers Fasteners.
 5. Unistrut; Atkore International.
- B. Provide preset concrete inserts that are seismically prequalified in accordance with ICC-ES AC446 testing.
- C. Comply with MSS SP-58.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive seismic control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install where where required to prevent buckling of hanger rods caused by seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Select sizes of components so strength will be adequate to carry static and seismic loads within specified loading limits.

3.3 INSTALLATION OF SEISMIC-RESTRAINT DEVICES

- A. Provide seismic restraint devices for systems and equipment where indicated in Equipment Schedules or Seismic and Wind-Load Controls Schedule, where indicated on Drawings, where the Specifications indicate they are to be installed on specific equipment and systems, and where required by applicable codes.
 - 1. Install equipment and devices to withstand the effects of earthquake motions.
- B. Coordinate location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- C. Installation of seismic restraints must not cause any stresses, misalignment, or change of position of equipment or conduits.
- D. Equipment Restraints:
 - 1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Raceway, Cable, Wireway, Cable Tray, and Busway Support and Hanger Restraints:

1. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 2. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.
- G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- I. Post-Installed Concrete Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 3. Mechanical-Type Anchor Bolts: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors must be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 4. Adhesive-Type Anchor Bolts: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 5. Set anchors to manufacturer's recommended torque using a torque wrench.
 6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where connection is terminated to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.

3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test no fewer than four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.

B. Nonconforming Work:

1. Seismic controls will be considered defective if they do not pass tests and inspections.
2. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Labels.
2. Tapes.
3. Tags.
4. Signs.
5. Cable ties.
6. Miscellaneous identification products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1.

B. Comply with 29 CFR 1910.144 for color identification of hazards; 29 CFR 1910.145 for danger, caution, warning, and safety instruction signs and tags; and the following:

1. Fire-protection and fire-alarm equipment, including raceways, must be finished, painted, or suitably marked safety red.

C. Signs, labels, and tags required for personnel safety must comply with the following standards:

1. Safety Colors: NEMA Z535.1.
2. Facility Safety Signs: NEMA Z535.2.
3. Safety Symbols: NEMA Z535.3.
4. Product Safety Signs and Labels: NEMA Z535.4.
5. Safety Tags and Barricade Tapes for Temporary Hazards: NEMA Z535.5.

D. Comply with NFPA 70E and Section 260573 "Electrical System Studies" requirements for arc-flash warning labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, must comply with UL 969.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 1000 V or Less:

1. White letters on colored background. Refer to Part 3 for colors.

2. Legend: Indicate voltage and system or service type.
- B. Color-Coding for Phase- and Voltage-Level Identification, 1000 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
1. Color must be factory applied or field applied for sizes larger than 8 AWG if authorities having jurisdiction permit.
 2. Colors for 208Y/120 V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 3. Colors for 480Y/277 V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 4. Color for Neutral: White.
 5. Color for Equipment Grounds: Green.
- C. Warning Label Colors:
1. Identify system voltage with white letters on orange background.
- D. Warning labels and signs must include, but are not limited to, the following legends:
1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
- E. Equipment Identification Labels:
1. White letters on colored background. Refer to Part 3 for colors.

2.3 LABELS

- A. Self-Adhesive Wraparound Labels: Preprinted, 3 mil thick, flexible label with acrylic pressure-sensitive adhesive.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. Grafoplast Wire Markers.
 - e. Ideal Industries, Inc.
 - f. LEM Products Inc.
 - g. Marking Services Inc.

- h. [Panduit Corp.](#)
 - i. [Seton Identification Products; a Brady Corporation company.](#)
 - j. [emedco.](#)
2. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over legend. Labels sized such that clear shield overlaps entire printed legend.
 3. Marker for Labels:
 - a. Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- B. Self-Adhesive Labels: 3 mil thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. [A'n D Cable Products.](#)
 - b. [Brady Corporation.](#)
 - c. [Brother International Corporation.](#)
 - d. [Grafoplast Wire Markers.](#)
 - e. [HellermannTyton.](#)
 - f. [Ideal Industries, Inc.](#)
 - g. [LEM Products Inc.](#)
 - h. [Marking Services Inc.](#)
 - i. [Panduit Corp.](#)
 - j. [Seton Identification Products; a Brady Corporation company.](#)
 - k. [emedco.](#)
 2. Minimum Nominal Size:
 - a. 1-1/2 by 6 inch for raceway and conductors.
 - b. 3-1/2 by 5 inch for equipment.

2.4 TAPES

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
1. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. [Carlton Industries, L.P.](#)
 - c. [Champion America.](#)
 - d. [HellermannTyton.](#)
 - e. [Ideal Industries, Inc.](#)
 - f. [Marking Services Inc.](#)

- g. [Panduit Corp.](#)
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mil thick by 1 to 2 inch wide; compounded for outdoor use.
- 1. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. [Carlton Industries, LP.](#)
 - c. [Marking Services Inc.](#)
 - d. [emedco.](#)
- C. Underground-Line Warning Tape:
- 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. [Brady Corporation.](#)
 - b. [Ideal Industries, Inc.](#)
 - c. [LEM Products Inc.](#)
 - d. [Marking Services Inc.](#)
 - e. [Pipemarker.com; Brimar Industries, Inc.](#)
 - f. [Reef Industries, Inc.](#)
 - g. [Seton Identification Products; a Brady Corporation company.](#)
 - 2. Tape:
 - a. Recommended by manufacturer for method of installation and suitable to identify and locate underground electrical utility lines.
 - b. Printing on tape must be permanent and may not be damaged by burial operations.
 - c. Tape material and ink must be chemically inert and not be subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
 - 3. Color and Printing:
 - a. Comply with APWA Uniform Color Code using NEMA Z535.1 safety colors.
 - b. Inscriptions for Red Tapes: "CAUTION BURIED ELECTRIC LINE BELOW".
 - 4. Tape Type ID:
 - a. Detectable three-layer laminate, consisting of printed pigmented polyolefin film, solid aluminum-foil core, and clear protective film that allows inspection of continuity of conductive core; bright colored, compounded for direct-burial service.
 - b. Width: 3 inch.
 - c. Overall Thickness: 5 mil.
 - d. Foil Core Thickness: 0.35 mil.

- e. Weight: 28 lb/1000 sq. ft.
- f. Tensile in accordance with ASTM D882: 70 lbf and 4600 psi.

2.5 TAGS

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
 - 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. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Marking Services Inc.
 - d. Seton Identification Products; a Brady Corporation company.
 - e. emedco.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
 - 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. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Grafoplast Wire Markers.
 - d. LEM Products Inc.
 - e. Marking Services Inc.
 - f. Panduit Corp.
 - g. Seton Identification Products; a Brady Corporation company.
 - h. emedco.
- C. Laminated Acrylic or Melamine Plastic Signs:
 - 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. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Marking Services Inc.
 - d. Seton Identification Products; a Brady Corporation company.
 - e. emedco.
 - 2. Engraved legend.
 - 3. Thickness:
 - a. For signs up to 20 sq. inch, minimum 1/16 inch thick.

- b. For signs larger than 20 sq. inch, 1/8 inch thick.
- c. Engraved legend with white letters on a colored background. Refer to Part 3 for colors and information.
- d. Self-adhesive.
- e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 CABLE TIES

- 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. HellermannTyton.
 - 2. Ideal Industries, Inc.
 - 3. Marking Services Inc.
 - 4. Panduit Corp.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black, except where used for color-coding.
- C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black.
- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F in accordance with ASTM D638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

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 electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.
- G. System Identification for Raceways and Cables under 1000 V: Identification must completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.
 - 1. Secure tight to surface of conductor, cable, or raceway.
- H. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
- I. Emergency Operating Instruction Signs: Install instruction signs with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.
- J. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from floor.
- K. Accessible Fittings for Raceways: Identify cover of junction and pull box of the following systems with wiring system legend and system voltage. System legends and colors must be as follows:
 - 1. Fire Alarm, Red.
 - 2. Normal Power, Green.
 - 3. Life Safety Branch, Orange.
 - 4. Critical Branch, Yellow.

5. Equipment Branch, Blue.
 6. UPS Branch, Purple.
 7. Low Voltage Rough-ins, Silver.
- L. Self-Adhesive Wraparound Labels: Secure tight to surface at location with high visibility and accessibility.
- M. Self-Adhesive Labels:
1. Install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 2. Unless otherwise indicated, provide single line of text with 1/2 inch high letters on 1-1/2 inch high label; where two lines of text are required, use labels 2 inch high.
- N. Self-Adhesive Vinyl Tape: Secure tight to surface at location with high visibility and accessibility.
1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for minimum distance of 6 inch where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.
- O. Underground Line Warning Tape:
1. Install underground-line warning tape for cables in raceways.
- P. Metal Tags:
1. Place in location with high visibility and accessibility.
 2. Secure using general-purpose cable ties.
- Q. Nonmetallic Preprinted Tags:
1. Place in location with high visibility and accessibility.
 2. Secure using general-purpose cable ties.
- R. Laminated Acrylic or Melamine Plastic Signs:
1. Attach signs that are not self-adhesive type with mechanical fasteners appropriate to location and substrate.
 2. Unless otherwise indicated, provide four lines of text with 1/2 inch high letters on 3 inch high sign.
- S. Cable Ties: General purpose, for attaching tags, except as listed below:
1. Outdoors: UV-stabilized nylon.
 2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION 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 of high visibility. Identify by system and circuit designation.
- C. Accessible Raceways and Metal-Clad Cables, 1000 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive raceway labels.
 - 1. Locate identification at changes in direction, at penetrations of walls and floors, at 50 ft maximum intervals in straight runs, and at 25 ft maximum intervals in congested areas.
- D. Accessible Fittings for Raceways and Cables within Buildings: Identify cover of junction and pull box of the following systems with self-adhesive labels containing wiring system legend and system voltage. System legends and color must be as follows:
 - 1. Fire Alarm, Red.
 - 2. Normal Power, Green.
 - 3. Life Safety Branch, Orange.
 - 4. Critical Branch, Yellow.
 - 5. Equipment Branch, Blue.
 - 6. UPS Branch, Purple.
 - 7. Low Voltage Rough-ins, Silver.
- E. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive labels with conductor or cable designation, origin, and destination.
- F. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive labels with conductor designation.
- G. Conductors to Be Extended in Future: Attach write-on tags to conductors and list source.
- H. Auxiliary Electrical Systems Conductor Identification: Self-adhesive vinyl tape that is uniform and consistent with system used by manufacturer for factory-installed connections.
 - 1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
- I. Locations of Underground Lines: Underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
- J. Instructional Signs: Self-adhesive labels, including color code for grounded and ungrounded conductors.
- K. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive labels.

1. Apply to exterior of door, cover, or other access.
 2. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- L. Arc Flash Warning Labeling: Self-adhesive labels.
- M. Operating Instruction Signs: Self-adhesive labels.
- N. Emergency Operating Instruction Signs: Self-adhesive labels with white legend on red background with minimum 3/8 inch high letters for emergency instructions at equipment used for power transfer.
- O. Equipment Identification Labels:
1. Type: Laminated acrylic or melamine plastic sign.
 2. Information:
 - a. Equipment Name
 - b. Branch (Normal, Life Safety, Critical, or Equipment)
 - c. Source Fed From
 - d. Voltage
 3. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in location provided by panelboard manufacturer. Panelboard identification must be in form of self-adhesive, engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchgear.
 - e. Switchboards.
 - f. Transformers: Label that includes tag designation indicated on Drawings for transformer, feeder, and panelboards or equipment supplied by secondary.
 - g. Emergency system boxes and enclosures.
 - h. Enclosed switches.
 - i. Enclosed circuit breakers.
 - j. Variable-speed controllers.
 - k. Push-button stations.
 - l. Power-transfer equipment.
 - m. Contactors.
 - n. Remote-controlled switches, dimmer modules, and control devices.
 - o. Power-generating units.
 - p. Monitoring and control equipment.
 - q. UPS equipment.

END OF SECTION 260553

SECTION 260573 – ELECTRICAL SYSTEM STUDIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Computer-based, fault-current study to determine minimum interrupting capacity of circuit protective devices.
2. Computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.
3. Computer-based, arc-flash study to determine arc-flash hazard distance and incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 SUBMITTALS

A. Combined Electrical Systems Study Report:

1. A single, combined report may be submitted containing all the information listed in this section in lieu of separate reports.

B. Short-Circuit Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.
 - a. Short-circuit study input data, including completed computer program input data sheets.

C. Coordination Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
 - c. Submit study report for action prior to receiving final approval of distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that selection of devices and associated characteristics is satisfactory.

D. Arc-Flash Study Report:

1. Submit the following after approval of system protective devices submittals. Submittals must be in digital form:
 - a. Arc-flash study input data, including completed computer program input data sheets.
- E. Revised one-line diagram, reflecting field investigation results and results of study.

1.3 QUALITY ASSURANCE

- A. Study must be performed using commercially developed and distributed software designed specifically for power system analysis.
- B. Software algorithms must comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. CGI CYME.
 2. EasyPower, LLC (formerly ESA Inc.).
 3. EDSA Micro Corporation.
 4. ESA Inc.
 5. ETAP - Digital Twin Platform.
 6. Power Analytics, Corporation.
 7. SKM Systems Analysis, Inc.
- B. Comply with IEEE 399 and IEEE 551.
- C. Analytical features of power systems analysis software program must have capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.
- D. Computer software program must be capable of plotting and diagramming time-current-characteristic curves as part of its output.
- E. Computer program must be designed to perform short-circuit studies or have function, component, or add-on module designed to perform short-circuit studies.
- F. Computer program must be developed under supervision of licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

2.2 SHORT-CIRCUIT STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kVA and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations and ratings.
 - 6. Derating factors and environmental conditions.
 - 7. Any revisions to electrical equipment required by study.
- D. Comments and recommendations for system improvements or revisions in written document, separate from one-line diagram.
- E. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to available short-circuit currents. Verify that equipment withstand ratings exceed available short-circuit current at equipment installation locations.
 - 2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
 - 3. For 600 V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
 - 4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in standards to 1/2-cycle symmetrical fault current.
 - 5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
- F. Short-Circuit Study Input Data:
 - 1. Power sources available.
 - 2. Manufacturer, model, and interrupting rating of protective devices.
 - 3. Conductors.
 - 4. Transformer data.
- G. Short-Circuit Study Output Reports:
 - 1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.

- d. Equivalent impedance.
- 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
- 3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.

2.3 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kVA and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, and panelboard designations.
 - 6. Revisions to electrical equipment required by study.
 - 7. Study Input Data.
- D. Protective Device Coordination Study:
 - 1. Report recommended settings of protective devices, ready to be applied in field. Use manufacturer's data sheets for recording recommended setting of overcurrent protective devices when available.
 - a. Phase and Ground Relays:

- 1) Device tag.
 - 2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
 - 3) Recommendations on improved relaying systems, if applicable.
- b. Circuit Breakers:
- 1) Adjustable pickups and time delays (long time, short time, and ground).
 - 2) Adjustable time-current characteristic.
 - 3) Adjustable instantaneous pickup.
 - 4) Recommendations on improved trip systems, if applicable.
- c. Fuses: Show current rating, voltage, and class.
- E. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for switching schemes and for emergency periods where power source is local generation. Show the following information:
1. Device tag and title, one-line diagram with legend identifying portion of system covered.
 2. Terminate device characteristic curves at point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
 3. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
 4. Plot the following listed characteristic curves, as applicable:
 - a. Power utility's overcurrent protective device.
 - b. Medium-voltage equipment overcurrent relays.
 - c. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - d. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - e. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - f. Cables and conductors damage curves.
 - g. Ground-fault protective devices.
 - h. Motor-starting characteristics and motor damage points.
 - i. Generator short-circuit decrement curve and generator damage point.
 - j. Largest feeder circuit breaker in each motor-control center and panelboard.
 5. Maintain selectivity for tripping currents caused by overloads.
 6. Provide adequate time margins between device characteristics such that selective operation is achieved.
 7. Comments and recommendations for system improvements.

2.4 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary of study findings.

- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.
 - 3. Transformer kVA and voltage ratings, including derating factors and environmental conditions.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center, panelboard designations, and ratings.
- D. Study Input Data.
- E. Arc-Flash Study Output Reports:
 - 1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each equipment location included in report:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. No AC Decrement (NACD) ratio.
 - e. Equivalent impedance.
 - f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on symmetrical basis.
 - g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on total basis.
- F. Incident Energy and Flash Protection Boundary Calculations:
 - 1. Arcing fault magnitude.
 - 2. Protective device clearing time.
 - 3. Duration of arc.
 - 4. Arc-flash boundary.
 - 5. Restricted approach boundary.
 - 6. Limited approach boundary.
 - 7. Working distance.
 - 8. Incident energy.
 - 9. Hazard risk category.
 - 10. Recommendations for arc-flash energy reduction.
- G. Fault study input data, case descriptions, and fault-current calculations including definition of terms and guide for interpretation of computer printout.

2.5 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems" for self-adhesive equipment labels. Produce 3.5 by 5 inch self-adhesive equipment label for each work location included in analysis.

- B. Label must have orange header with wording, "WARNING, ARC-FLASH HAZARD," and must include the following information taken directly from arc-flash hazard analysis:
 - 1. Location designation.
 - 2. Nominal voltage.
 - 3. Protection boundaries.
 - a. Arc-flash boundary.
 - b. Restricted approach boundary.
 - c. Limited approach boundary.
 - 4. Arc flash PPE category.
 - 5. Required minimum arc rating of PPE in Cal/cm squared.
 - 6. Available incident energy.
 - 7. Working distance.
 - 8. Engineering report number, revision number, and issue date.
- C. Labels must be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies: Perform Short-Circuit and Protective Device Coordination studies prior to starting Arc-Flash Hazard Analysis.
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article.
 - 2. Coordination Study Report Contents: As specified in "Coordination Study Report Contents" Article.
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. Maximum calculation must assume maximum contribution from utility and must assume motors to be operating under full-load conditions.
 - 2. Calculate arc-flash energy at 85 percent of maximum short-circuit current in accordance with IEEE 1584 recommendations.
- D. Calculate arc-flash protection boundary and incident energy at locations in electrical distribution system where personnel could perform work on energized parts.
- E. Include medium- and low-voltage equipment locations, except equipment fed from transformers smaller than 75 kVA.
- F. Calculate limited, restricted, and prohibited approach boundaries for each location.
- G. Incident energy calculations must consider accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations must take into

account changing current contributions, as sources are interrupted or decremented with time. Fault contribution from motors and generators must be decremented as follows:

1. Fault contribution from induction motors must not be considered beyond three to five cycles.
 2. Fault contribution from synchronous motors and generators must be decayed to match actual decrement of each as closely as possible (for example, contributions from permanent magnet generators will typically decay from 10 p.u. to 3 p.u. after 10 cycles).
- H. Arc-flash energy must generally be reported for maximum of line or load side of circuit breaker. However, arc-flash computation must be performed and reported for both line and load side of circuit breaker as follows:
1. When circuit breaker is in separate enclosure.
 2. When line terminals of circuit breaker are separate from work location.
- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.2 POWER SYSTEM DATA

- A. Obtain data necessary for conduct of study.
1. Verify completeness of data supplied on one-line diagram. Call discrepancies to Architect's attention.
 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
 3. For equipment that is existing to remain, obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers in accordance with NFPA 70E.
- B. Gather and tabulate required input data to support short-circuit study. Comply with requirements in Section 017839 "Project Record Documents" for recording circuit protective device characteristics. Record data on Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to amount of detail that is required to be acquired in field. Field data gathering must be by, or under supervision of, qualified electrical professional engineer. Data include, but are not limited to, the following:
1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at service.
 3. Power sources and ties.
 4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
 5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
 6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.

7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Derating factors.
11. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
12. Medium-voltage cable sizes, lengths, conductor material, cable construction, metallic shield performance parameters, and conduit material (magnetic or nonmagnetic).
13. Data sheets to supplement electrical distribution system one-line diagram, cross-referenced with tag numbers on diagram, showing the following:
 - a. Special load considerations, including starting inrush currents and frequent starting and stopping.
 - b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
 - c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
 - d. Generator thermal-damage curve.
 - e. Ratings, types, and settings of utility company's overcurrent protective devices.
 - f. Special overcurrent protective device settings or types stipulated by utility company.
 - g. Time-current-characteristic curves of devices indicated to be coordinated.
 - h. Manufacturer, frame size, interrupting rating in amperes root mean square (rms) symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
 - i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
 - j. Switchgear, switchboards, motor-control centers, and panelboards ampacity, and SCCR in amperes rms symmetrical.
 - k. Identify series-rated interrupting devices for condition where available fault current is greater than interrupting rating of downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.3 SHORT-CIRCUIT STUDY

- A. Perform study following general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Begin short-circuit current analysis at service, extending down to system overcurrent protective devices as follows:
 1. To normal system low-voltage load buses where fault current is 5 kA or less.
 2. Exclude equipment supplied by single transformer smaller than 75 kVA.

- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- G. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
- H. Include in report identification of protective device applied outside its capacity.

3.4 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Begin analysis at service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 5 kA or less.
- E. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- F. Transformer Primary Overcurrent Protective Devices:
 - 1. Device must not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 - 2. Device settings must protect transformers according to IEEE C57.12.00, for fault currents.
- G. Motor Protection:
 - 1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
 - 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

- H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands maximum short-circuit current for time equivalent to tripping time of primary relay protection or total clearing time of fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- I. Generator Protection: Select protection according to manufacturer's instructions and to IEEE 242.
- J. Include ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and apply to low- and medium-voltage, three-phase ac systems. Also account for fault-current dc decrement, to address asymmetrical requirements of interrupting equipment.
- K. Calculate short-circuit momentary and interrupting duties for three-phase bolted fault and single line-to-ground fault at each equipment indicated on one-line diagram.
 - 1. For grounded systems, provide bolted line-to-ground fault-current study for areas as defined for three-phase bolted fault short-circuit study.
- L. Protective Device Evaluation:
 - 1. Evaluate equipment and protective devices and compare to short-circuit ratings.
 - 2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
 - 3. Include in report identification of protective device applied outside its capacity.

3.5 FIELD ADJUSTING

- A. Adjust relay and protective device settings according to recommended settings provided by coordination study. Field adjustments must be completed by engineering service division of equipment manufacturer under "Startup and Acceptance Testing" contract portion.
- B. Make minor modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.
- C. Testing and adjusting must be by qualified low-voltage electrical testing and inspecting agency.
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for adjustable overcurrent protective devices.

3.6 LABELING

- A. Apply arc-flash label on front cover for each equipment included in study. Base arc-flash label data on highest values calculated at each location.
- B. Each piece of equipment listed below not fed by single transformer smaller than 75 kVA must have arc-flash label applied to it:

1. Switchboards.
2. Panelboards.
3. Low voltage transformers.
4. Safety switches.
5. Control panels.

C. Note on record Drawings location of equipment where personnel could be exposed to arc-flash hazard during their work.

1. Indicate arc-flash energy.
2. Indicate protection level required.

3.7 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels under direct supervision and control of qualified electrical professional engineer.

END OF SECTION 260573

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Indoor occupancy and vacancy sensors.
 - 2. Switchbox-mounted occupancy sensors.
 - 3. Conductors and cables.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
 - 2. Interconnection diagrams showing field-installed wiring.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Power Wiring to Supply Side of Remote-Control Power Sources: No. 12 AWG or larger.
- C. Classes 2 and 3 Control Cable: Multiconductor cable with No. 24 AWG or larger conductors.
- D. Class 1 Control Cable: Multiconductor cable with No. 18 AWG or larger conductors.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF SENSORS

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.

3.3 INSTALLATION OF WIRING

- A. Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Size conductors in accordance with lighting control device manufacturer's instructions unless otherwise indicated.
- C. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, device, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring in accordance with Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
- B. Nonconforming Work:
 - 1. Lighting control devices will be considered defective if they do not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- C. Prepare test and inspection reports.

END OF SECTION 260923

SECTION 262213 - LOW-VOLTAGE DISTRIBUTION TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution, dry-type transformers with nominal primary and secondary rating of 600 V and less, with capacities up to 1500 kVA.

1.2 SUBMITTALS

A. Product Data: For each transformer.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Inspection: On receipt, inspect for and note shipping damage to packaging and transformer.

1. If manufacturer packaging is removed for inspection, and transformer will be stored after inspection, re-package transformer using original or new packaging materials that provide protection equivalent to manufacturer's packaging.

B. Storage: Store in warm, dry, and temperature-stable location in original shipping packaging.

C. Handling: Follow manufacturer's instructions for lifting and transporting transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ABB, Electrification Business.
2. Acme Electric; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
3. Eaton.
4. Prolec GE; A Xignux and General Electric Company Joint Venture.
5. Siemens Industry, Inc., Energy Management Division.
6. Square D; Schneider Electric USA.

B. Source Limitations: Obtain each type of transformer from single source from single manufacturer.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60 Hz service.
- B. Electrical Components, Devices, and Accessories: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- C. Transformers Rated 15 kVA and Larger:
 - 1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
 - 2. Marked as compliant with DOE 2016 efficiency levels by qualified electrical testing laboratory recognized by authorities having jurisdiction.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NFPA 70, and list and label as complying with UL 1561.
- B. Cores: Electrical grade, non-aging silicon steel with high permeability and low hysteresis losses.
 - 1. One leg per phase.
 - 2. Grounded to enclosure.
- C. Coils: Continuous windings except for taps.
 - 1. Coil Material: Aluminum.
- D. Encapsulation: Transformers smaller than 30 kVA must have core and coils completely resin encapsulated.
- E. Enclosure: Ventilated.
 - 1. Core and coil must be encapsulated within resin compound to seal out moisture and air.
 - 2. KVA Ratings: Based on convection cooling only and not relying on auxiliary fans.
 - 3. Wiring Compartment: Sized for conduit entry and wiring installation.
 - 4. Environmental Protection:
 - a. Indoor: UL 50E, Type 1.
 - 5. Finish Color: Gray weather-resistant enamel.
- F. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.
- G. Insulation Class, 30 kVA and Larger: 220 deg C, UL-component-recognized insulation system with maximum of 150 deg C rise above 40 deg C ambient temperature.
- H. Grounding: Provide ground-bar kit or ground bar installed on inside of transformer enclosure.

2.4 IDENTIFICATION

A. Nameplates:

1. Engraved, laminated-acrylic or melamine plastic signs for distribution transformers, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 260553 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for transformers.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's published instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Section 260526 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance must be 5 Ω at location of transformer.
- E. Environment: Enclosures must be rated for environment in which they are located. Covers for UL 50E, Type 4X enclosures may not cause accessibility problems.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install transformers level and plumb on concrete base with vibration-dampening supports.
- B. Construct concrete bases and anchor floor-mounted transformers in accordance with manufacturer's published instructions, seismic requirements applicable to Project, and requirements in Section 260529 "Hangers and Supports for Electrical Systems."
 1. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- C. Secure transformer to concrete base in accordance with manufacturer's published instructions.
- D. Secure covers to enclosure and tighten bolts to manufacturer-recommended torques to reduce noise generation.
- E. Remove shipping bolts, blocking, and wedges.

3.3 CONNECTIONS

- A. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Tighten electrical connectors and terminals in accordance with manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- D. Provide flexible connections at conduit and conductor terminations and supports to eliminate sound and vibration transmission to building structure.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Small (Up to 167 kVA Single-Phase or 500 kVA Three-Phase) Dry-Type Transformer Field Tests:
 - a. Visual and Mechanical Inspection.
 - 1) Inspect physical and mechanical condition.
 - 2) Inspect anchorage, alignment, and grounding.
 - 3) Verify that resilient mounts are free and that shipping brackets have been removed.
 - 4) Verify that unit is clean.
 - 5) Perform specific inspections and mechanical tests recommended by manufacturer.
 - 6) Verify that as-left tap connections are as specified.
 - 7) Verify presence of surge arresters and that their ratings are as specified.
 - b. Electrical Tests:
 - 1) Measure resistance at windings, taps, and bolted connections.
 - 2) Perform insulation-resistance tests winding-to-winding and windings-to-ground. Apply voltage in accordance with manufacturer's published data. In absence of manufacturer's published data, comply with NETA ATS, Table 100.5. Calculate polarization index: value of index may not be less than 1.0.
 - 3) Perform turns-ratio tests at tap positions. Test results may not deviate by more than one-half percent from either adjacent coils or calculated ratio. If test fails, replace transformer.
 - 4) Verify correct secondary voltage, phase-to-phase and phase-to-neutral, after energization and prior to loading.
- B. Test Labeling: On completion of satisfactory testing of units, attach dated and signed "Satisfactory Test" label to tested components.

C. Nonconforming Work:

1. Transformer will be considered defective if it does not pass tests and inspections.
2. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Assemble and submit test and inspection reports.

3.5 ADJUSTING

- A. Record transformer secondary voltage at unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 5 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare written report recording output voltages and tap settings.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262213

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.2 SUBMITTALS

A. Product Data: For each panelboard.

B. 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.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: ISO 9001 or ISO 9002 certified.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Handle and prepare panelboards for installation according to NECA 407.

1.5 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.

- B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than seven days in advance of proposed interruption of electric service.
 - 2. Do not proceed with interruption of electric service without Construction Manager's written permission.
 - 3. Comply with NFPA 70E.

PART 2 - PRODUCTS

2.1 PANELBOARDS AND LOAD CENTERS COMMON REQUIREMENTS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.
- F. Enclosures: Flush and/or Surface-mounted, dead-front cabinets.
 - 1. Refer to panelboard schedules for arrangement.
 - 2. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 3. Height: 84 inches maximum.
 - 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
 - 5. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
- G. Phase, Neutral, and Ground Buses:
 - 1. Material:
 - a. 400 amperes and less: Tin-plated aluminum.
 - b. Greater than 400 amperes: Hard-drawn copper, 98 percent conductivity.

2. Plating shall run entire length of bus.
3. Bus shall be fully rated the entire length.
4. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
5. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
6. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.

H. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Terminations shall allow use of 75 deg C rated conductors without derating.
2. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
3. Main and Neutral Lugs: Compression type, with a lug on the neutral bar for each pole in the panelboard.
4. Ground Lugs and Bus-Configured Terminators: Compression type, with a lug on the bar for each pole in the panelboard.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.3 DISTRIBUTION PANELS

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

1. ABB, Electrification Business.
2. Eaton.
3. Siemens Industry, Inc., Energy Management Division.

4. [Square D; Schneider Electric USA.](#)
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers.

2.4 PANELBOARDS

- A. [Manufacturers:](#) Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. [ABB, Electrification Business.](#)
 2. [Eaton.](#)
 3. [Siemens Industry, Inc., Energy Management Division.](#)
 4. [Square D; Schneider Electric USA.](#)
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- D. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 3. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.

- e. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- f. Shunt Trip: 24-V trip coil energized from separate circuit, set to trip at 75percent of rated voltage.
- g. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
- h. Multipole units enclosed in a single housing with a single handle.
- i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.6 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Computer-generated circuit directory mounted inside panelboard door with transparent plastic protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

- B. Comply with NECA 1.
- C. Receive, inspect, handle, store, and install panelboards according to NECA 407.
- D. Equipment Mounting:
 - 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
 - 2. Comply with requirements for seismic control devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. For panelboards shorter than 68 inches, mount top of trim 72 inches above finished floor unless otherwise indicated. For all other panelboards, mount bottom of trim 4 inches above finished floor; however, the highest breaker shall not exceed 79 inches above finished floor.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- J. Install filler plates in unused spaces.
- K. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Do not perform optional tests. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573.16 "Coordination Studies."
- C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.
 - 1. Measure loads during period of normal facility operations.
 - 2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 - 3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
 - 4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

END OF SECTION 262416

SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes work to accommodate utility company revenue meters.

1.2 COORDINATION

- A. Electrical Service Connections:
 - 1. Coordinate with utility company, North Georgia EMC, and utility-furnished components.
 - a. Comply with requirements of utility providing electrical power services.
 - b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

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 916.

2.2 UTILITY METERING INFRASTRUCTURE

- A. Install metering accessories furnished by the utility company, complying with its requirements.
- B. Utility-Furnished Meters: Connect data transmission facility of metering equipment installed by the Utility.
 - 1. Data Transmission: Transmit pulse data over control-circuit conductors, classified as Class 1 per NFPA 70, Article 725. Comply with Section 260523 "Control-Voltage Electrical Power Cables."
- C. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
- D. Meter Sockets:
 - 1. Comply with requirements of electrical-power utility company.
 - 2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

E. Arc-Flash Warning Labels;

1. Labels: Comply with requirements for "Arc-Flash Warning Labels" in Section 260573 "Electrical System Studies." Apply a 3-1/2-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis.
2. Labels: Comply with requirements for "Self-Adhesive Equipment Labels" and "Signs" in Section 260553 "Identification for Electrical Systems." Apply a 3-1/2-by-5-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis. Labels shall be machine printed, with no field-applied markings.
 - a. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
 - 1) Location designation.
 - 2) Nominal voltage.
 - 3) Flash protection boundary.
 - 4) Hazard risk category.
 - 5) Incident energy.
 - 6) Working distance.
 - 7) Engineering report number, revision number, and issue date.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- C. Install arc-flash labels as required by NFPA 70.
- D. Wiring Method:
 1. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 271513 "Communications Copper Horizontal Cabling."
 2. Minimum conduit size shall be 1/2 inch.

END OF SECTION 262713

SECTION 262719 - MULTI-OUTLET ASSEMBLIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Wall-mounted, surface metal raceway multi-outlet assemblies.
2. Indoor service poles.

1.2 SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED, SURFACE METAL RACEWAY MULTI-OUTLET ASSEMBLIES

- A. Description: Two-piece surface metal raceway, field assembled and wired or with factory-wired multi-outlet harness, including outlets.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
1. Reference Standards: UL 5 for exposed power raceway and fittings. Multi-outlet assemblies used for communications or data must also comply with UL 5C for exposed communications raceway and fittings, and UL 2024 for communications cable routing.
 2. Provide separate paths for management of telecommunications and power cables.
- D. Source Limitations: Obtain products from single manufacturer designed for use as complete, matching assembly of raceways, receptacles, and switches.
- E. Wall-Mounted, Surface Metal Raceway Power Multi-Outlet Assembly:
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. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - b. Wiremold; Legrand North America, LLC.

2. Options:
 - a. Material: Steel, with manufacturer's standard finish.
 - b. Color:
 - 1) Normal Power: White.
 - 2) Critical Power: Red.
 - c. Power Outlets: 5-20R in accordance with Section 262726 "Wiring Devices."
 - d. Power Outlet Spacing: 12 inch.
 - e. Wiring: Single circuit in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

2.2 INDOOR SERVICE POLES

- A. Description: Factory-assembled and -wired, exposed raceway and fittings to route electrical wiring from connections above ceiling to outlets below ceiling.
- B. Regulatory Requirements: Listed and labeled in accordance with NFPA 70 by qualified electrical testing laboratory recognized by authorities having jurisdiction and marked for intended location and application.
- C. General Characteristics:
 1. Reference Standards: UL 5 for exposed power raceway and fittings, and UL 2024 for communications raceway and fittings.
 2. Listed and labeled in accordance with NFPA 90A for installation in air-handling plenum spaces.
 3. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to above ceiling structural supports; with pole foot and carpet pad attachment.
 4. Provide barrier to separate channel for power wiring from channel for voice and data communication cabling.
- D. Indoor Service Pole:
 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. Hubbell Premise Wiring; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - b. Panduit Corp.
 2. Options:
 - a. Material: Steel.
 - b. Height: Floor to ceiling, and minimum 6" above ceiling.
 - c. Finish: Manufacturer's standard painted finish and trim combination.
 - 1) Color: White.

- d. Power Outlets: Number and receptacle types per the drawings in accordance with Section 262726 "Wiring Devices."
- e. Wiring: Multi circuit per the drawings in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- f. Voice and Data Communication Outlets: One blank insert with bushed cable opening complying with requirements in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 101 for installation requirements for steel raceways, except where requirements on Drawings or in this Section are stricter.
- B. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies.
- C. Provide terminations, adapters, boxes, and other fittings required for installation.
- D. Install surface raceway with a minimum 2 inch radius control at bend points.
- E. Secure metallic surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inch and with no fewer than two supports per straight raceway section. Support surface raceway in accordance with manufacturer's instructions. Tape and glue are unacceptable support methods.
- F. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and support.
- H. Comply with requirements in Section 260533 "Raceway and Boxes for Electrical Systems" for installation of raceways.
- I. Coordination with Other Work:
 - 1. Adjust locations of multi-outlet assemblies to suit arrangement of partitions and furnishings. Locate outlets to avoid blocking by supports, furnishings, and other architectural fixtures.
 - 2. Provide outlets with special requirements, such as GFCI, AFCI, or special environmental requirements, where required by Drawings or to meet codes.

3.2 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."

END OF SECTION 262719

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. General-use switches.
2. General-grade single straight-blade receptacles.
3. General-grade duplex straight-blade receptacles.
4. Hospital-grade straight-blade receptacles.
5. Receptacles with ground-fault protective devices.
6. Locking receptacles.
7. Special-purpose power outlet assemblies.

1.2 DEFINITIONS

- A. Commercial/Industrial-Use Cord Reel: A cord reel subject to severe use in factories, commercial garages, construction sites, and similar locations requiring a harder service-type cord.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 GENERAL-USE SWITCHES

A. Toggle Switch:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:

- a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 3. General Characteristics:
 - a. Reference Standards: UL CCN WMUZ and UL 20.
- 4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration:
 - 1) Extra-heavy-duty, 120-277 V, 20 A. Poles per drawings.
- 5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.2 GENERAL-GRADE SINGLE STRAIGHT-BLADE RECEPTACLES

A. Single Straight-Blade Receptacle:

- 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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
- 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
- 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
- 4. Options:

- a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration:
 - 1) Extra-heavy-duty, NEMA arrangement per drawings.
5. Accessories:
- a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.3 GENERAL-GRADE DUPLEX STRAIGHT-BLADE RECEPTACLES

A. Duplex Straight-Blade Receptacle:

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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration:
 - 1) Heavy-duty, NEMA 5-20R.
 - 2) Extra-heavy-duty, NEMA arrangement per drawings.

5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Tamper-Resistant Duplex Straight-Blade Receptacle:

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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration:
 - 1) Heavy-duty, NEMA 5-20R.
5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.4 HOSPITAL-GRADE STRAIGHT-BLADE RECEPTACLES

A. Hospital-Grade, Non-Ferrous Duplex Straight-Blade Receptacle:

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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration: Extra-heavy-duty, NEMA 5-20R.
5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

B. Hospital-Grade Duplex Straight-Blade Receptacle:

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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.

3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration:
 - 1) Extra-heavy-duty, NEMA 5-20R.
5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.5 RECEPTACLES WITH GROUND-FAULT PROTECTIVE DEVICES

- A. General-Grade, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:
 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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN KCXX, UL 498, and UL 943.
 4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.

- b. Configuration: Heavy-duty, NEMA 5-20R.
- 5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.
- B. General-Grade, Weather-Resistant, Tamper-Resistant Duplex Straight-Blade Receptacle with GFCI Device:
 - 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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 - 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 3. General Characteristics:
 - a. Reference Standards: UL CCN KCXS, UL 498, and UL 943.
 - 4. Options:
 - a. Device Color:
 - 1) Normal Power: White
 - 2) Critical Power: Red.
 - b. Configuration: Heavy-duty, NEMA 5-20R.
 - 5. Accessories:
 - a. Cover Plate: 0.060 inch thick, high-impact thermoplastic (nylon) with smooth finish and color matching wiring device; from same manufacturer as wiring device.
 - b. Securing Screws for Cover Plate: Metal with head color matching wallplate finish.

2.6 LOCKING RECEPTACLES

- A. NEMA, 125 V, Locking Receptacle:

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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 4. Options:
 - a. Device Color: Black with yellow voltage indication on face.
 - b. Configuration: 2 pole, 3 wire, grounding, NEMA arrangement per drawings.
- B. NEMA, 250 V, Locking Receptacle **<Insert drawing designation>**:
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. Arrow Hart, Wiring Devices; Eaton, Electrical Sector.
 - b. Hubbell Wiring Device-Kellems; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour; Legrand North America, LLC.
 2. Regulatory Requirements:
 - a. Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 3. General Characteristics:
 - a. Reference Standards: UL CCN RTRT and UL 498.
 4. Options:
 - a. Device Color: Black with blue voltage indication on face.
 - b. Configuration:

- 1) 2 pole, 3 wire, grounding, NEMA arrangement per drawings.

2.7 SPECIAL-PURPOSE POWER OUTLET ASSEMBLIES

A. Spring-Driven Commercial/Industrial-Use Cord Reel, No. 12 AWG Conductors:

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. Appleton; Emerson Electric Co., Automation Solutions.
 - b. Ericson Manufacturing Company.
 - c. Gleason Reel; brand of Hubbell Electrical Solutions; Hubbell Incorporated.
 - d. Reelcraft Industries Inc.
2. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN SBCV and UL 355.
 - b. Spring take-up retraction mechanism.
4. Options:
 - a. Electrical Rating with Cable: 600 V, 20 A.
 - b. Color: Black.
 - c. Enclosure Degree of Protection: Type 4.
 - d. Ball stop.
 - e. Pivot base.
 - f. Spool Capacity:

- 1) No. 12 AWG, two wires and equipment ground, 20 ft.

B. Spring-Driven Cord Reel for Use in Class I Group D Hazardous Locations:

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. Appleton; Emerson Electric Co., Automation Solutions.
 - b. Conductix-Wampfler USA; Delachaux Group.
 - c. KH Industries, Inc.
2. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
3. General Characteristics:
 - a. Reference Standards: UL CCN SAOX and UL 355.

- b. Spring take-up retraction mechanism.
- 4. Options:
 - a. Electrical Rating with Cable: 600 V, 20 A.
 - b. Color: Black.
 - c. Enclosure Degree of Protection: Type 4.
 - d. Ball stop.
 - e. Pivot base.
 - f. Spool Capacity:
 - 1) No. 12 AWG, two wires and equipment ground, 20 ft.
 - 2) NEMA L18-30.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receptacles:

1. Verify that receptacles to be procured and installed for Owner-furnished equipment are compatible with mating attachment plugs on equipment.

B. Cord Reels:

1. Examine roughing-in for cord reel mounting and power connections to verify actual locations of mounts and power connections before cord reel installation.
2. Examine walls, floors, and ceilings for suitable conditions where cord reel will be installed.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF GFCI RECEPTACLES

- ##### A. Healthcare Facilities:
- Unless protection of downstream branch-circuit wiring, cord sets, and power-supply cords is required by NFPA 70 or NFPA 99, provide non-feed-through GFCI receptacles.

3.3 INSTALLATION OF SWITCHES

A. Comply with manufacturer's instructions.

B. Reference Standards:

1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
2. Consult Architect for resolution of conflicting requirements.

C. Identification:

1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with white-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.4 INSTALLATION OF STRAIGHT-BLADE RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 2. Receptacle Orientation: Unless otherwise indicated in Contract Documents, orient receptacle with ground up for vertical installations and to the left for horizontal installations.
 3. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."
 - a. Mark cover or cover plate using hot, stamped, or engraved machine printing with black-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
 - b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.5 INSTALLATION OF LOCKING RECEPTACLES

- A. Comply with manufacturer's instructions.
- B. Reference Standards:
 1. Unless more stringent requirements are specified in Contract Documents or manufacturers' instructions, comply with installation instructions in NECA NEIS 130.
 2. Consult Architect for resolution of conflicting requirements.
- C. Identification:
 1. Identify cover or cover plate for device with panelboard identification and circuit number in accordance with Section 260553 "Identification for Electrical Systems."

- a. Mark cover or cover plate with machine printing with **[black]** **[white]** **[red]**-filled lettering, and provide durable wire markers or tags inside device box or outlet box.
- b. Healthcare Facilities: Distinctively identify covers or cover plates of device boxes and outlet boxes that are supplied from life safety and critical branch power supplies following facility's standard practice.

3.6 INSTALLATION OF CORD REELS AND FITTINGS

- A. Comply with manufacturer's instructions.

3.7 FIELD QUALITY CONTROL OF SWITCHES

- A. Tests and Inspections:
 - 1. Perform tests and inspections in accordance with manufacturers' instructions.
- B. Nonconforming Work:
 - 1. Unit will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- C. Assemble and submit test and inspection reports.

3.8 FIELD QUALITY CONTROL OF STRAIGHT-BLADE RECEPTACLES

- A. Tests and Inspections:
 - 1. Insert and remove test plug to verify that device is securely mounted.
 - 2. Verify polarity of hot and neutral pins.
 - 3. Measure line voltage.
 - 4. Measure percent voltage drop.
 - 5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
 - 6. Healthcare Facilities: Test straight-blade receptacles in patient care spaces with receptacle pin tension test instrument in accordance with NFPA 99. Retention force of ground pin must be not less than 115 g (4 oz).
 - 7. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.
- B. Nonconforming Work:
 - 1. Device will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- C. Assemble and submit test and inspection reports.

3.9 FIELD QUALITY CONTROL OF LOCKING RECEPTACLES

- A. Tests and Inspections:

1. Insert and remove test plug to verify that device is securely mounted.
2. Verify polarity of hot and neutral pins.
3. Measure line voltage.
4. Measure percent voltage drop.
5. Measure grounding circuit continuity; impedance must be not greater than 2 ohms.
6. Perform additional installation and maintenance inspections and diagnostic tests in accordance with NECA NEIS 130 and manufacturers' instructions.

B. Nonconforming Work:

1. Device will be considered defective if it does not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.10 FIELD QUALITY CONTROL OF CORD REELS AND FITTINGS

A. Tests and Inspections:

1. Perform tests and inspections indicated in manufacturer's instructions.

B. Nonconforming Work:

1. Components and assemblies will be considered defective if they do not pass tests and inspections.
2. Remove and replace defective units and retest.

C. Assemble and submit test and inspection reports.

3.11 PROTECTION

A. Devices:

1. Schedule and sequence installation to minimize risk of contamination of wires and cables, devices, device boxes, outlet boxes, covers, and cover plates by plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other materials.
2. After installation, protect wires and cables, devices, device boxes, outlet boxes, covers, and cover plates from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

B. Cord Reels and Fittings:

1. After installation, protect cord reels and fittings from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600 V ac and less for use in the following:
 - a. Control circuits.
 - b. Enclosed controllers.
 - c. Enclosed switches.
2. Spare-fuse cabinets.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in other sections, include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse used on the Project. Submit in electronic format suitable for use in coordination software and in PDF format.
4. Coordination charts and tables and related data.

C. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Bussmann; Eaton, Electrical Sector.
2. Littelfuse, Inc.

3. Mersen USA.

- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 - 1. Type RK-5: 600-V, zero- to 600-A rating, 200 kAIC.
 - 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC.
 - 3. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
 - 4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

2.3 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 - 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 - 2. Finish: Gray, baked enamel.
 - 3. Identification: "SPARE FUSES" in 1-1/2-inch-high letters on exterior of door.
 - 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:

- 1. Motor Branch Circuits: Class RK5, time delay.
- 2. Large Motor Branch (601-4000 A): Class L, time delay.
- 3. Power Electronics Circuits: Class J, high speed.
- 4. Other Branch Circuits: Class RK5, time delay.
- 5. Control Transformer Circuits: Class CC, time delay, control transformer duty.
- 6. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install spare-fuse cabinet(s) in location shown on the Drawings or as indicated in the field by Construction Manager.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Enclosures.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For enclosed switches and circuit breakers.

1. Include plans, elevations, sections, details, and attachments to other work. Include required clearances and service clearance around the equipment. Show tabulations of installed devices, features and ratings. Include the following:
 - a. Enclosure types and details.
 - b. Current and voltage ratings.
 - c. Short-circuit current rating.
2. Include wiring diagrams for power, signal, and control wiring. Differentiate between manufacturer-installed and field-installed wiring.

C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - b. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device. Submit in electronic format suitable for use in coordination software and in PDF format.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 GENERAL REQUIREMENTS

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with NFPA 70.

2.3 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB, Electrification Business.
 - 2. Eaton.
 - 3. Siemens Industry, Inc., Energy Management Division.
 - 4. Square D; Schneider Electric USA.
- B. Type HD, Heavy Duty:
 - 1. Single throw.
 - 2. Poles, voltage, and amperage per drawings.
 - 3. UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses.
 - 4. Lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 4. Lugs: Compression type, suitable for number, size, and conductor material.

2.4 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. ABB, Electrification Business.
 2. Eaton.
 3. Siemens Industry, Inc., Energy Management Division.
 4. Square D; Schneider Electric USA.
- B. Type HD, heavy duty, air break, single throw, 600-V ac, suitable for motor circuits, number of poles as shown on the drawings. UL 98 and NEMA KS 1, with ampere rating as shown on the drawings.
- C. Design: safety type, housed in separate metallic enclosure with arc quenching devices on each pole.
- D. Features:
1. Short circuit withstand: Non-fusible switch shall be capable of withstanding the maximum short circuit current at the point of installation in combination with the upstream protective device.
 2. Operating Handle: A suitable handle made of conducting material shall be provided for safety and convenient operation, the handle shall have an electrical connection with the enclosure. The on/off position of the operating handle and switch contacts shall be clearly indicated.
 3. Operating Mechanism: Quick-make, quick-break, double contact rotary blade mechanism, independent manual operation.
 4. Mechanical Interlock: the box, cover and switch operating mechanism shall be mechanically interlocked so that the door cannot be opened when the switch contacts are in the closed position and the switch contacts cannot close when the door is open. Non-fusible switch shall be provided with an override for the interlock which can only be activated by a qualified person. The interlock mechanism shall be reactivated automatically when the enclosure door is closed.
 5. all be reactivated automatically when the enclosure door is closed.
 6. Padlocking: Means shall be provided for padlocking enclosures shut, they shall be provided to lock the switch with the contacts in the off position. The disconnect switch shall accommodate at least three padlocks. Any single padlock shall be capable of providing locking.
 7. Switch Disconnectors for Variable Frequency Drive (VFD) Motors: switch disconnectors connected to VFD motors shall have an auxiliary contact that switch off the VFD drive before disconnecting the motor.
 8. Spacing in enclosed switches shall meet the requirements of NEMA KS-1.
- E. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Compression type, suitable for number, size, and conductor material.

2.5 SHUNT TRIP SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Bussmann; Eaton, Electrical Sector.
 2. Littelfuse, Inc.
 3. Mersen USA.
- B. General Requirements: Comply with ASME A17.1, UL 50, and UL 98, with Class J fuse block and 200-kA interrupting and short-circuit current rating.
- C. Type HD, Heavy-Duty, Three Pole, Single-Throw Fusible Switch: Voltage and amperage per drawings; UL 98 and NEMA KS 1; integral shunt trip mechanism; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer of enough capacity to operate shunt trip, pilot, indicating and control devices.
- E. Accessories:
 1. Oiltight key switch for key-to-test function.
 2. Oiltight green ON pilot light.
 3. Isolated neutral lug; 100 percent rating.
 4. Form C alarm contacts that change state when switch is tripped.
 5. Three-pole, double-throw, fire-safety and alarm relay; 24-V dc coil voltage.
 6. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.
 7. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 8. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 9. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Contact rating - 24-V dc.
 10. Lugs: Compression type, suitable for number, size, and conductor material.

2.6 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: UL 489, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
- B. Enclosure Finish: The enclosure shall be finished with gray baked enamel paint, electrodeposited on cleaned, phosphatized steel (NEMA 250 Type 1) gray baked enamel paint, or electrodeposited on cleaned, phosphatized galvanized steel (NEMA 250 Types 3R, 12).

- C. Conduit Entry: NEMA 250 Types 4, 4X, and 12 enclosures shall contain no knockouts. NEMA 250 Types 7 and 9 enclosures shall be provided with threaded conduit openings in both endwalls.
- D. Operating Mechanism: The circuit-breaker operating handle shall be externally operable with the operating mechanism being an integral part of the box, not the cover. The cover interlock mechanism shall have an externally operated override. The override shall not permanently disable the interlock mechanism, which shall return to the locked position once the override is released. The tool used to override the cover interlock mechanism shall not be required to enter the enclosure in order to override the interlock.
- E. Enclosures designated as NEMA 250 Type 4, 4X stainless steel, 12, or 12K shall have a dual cover interlock mechanism to prevent unintentional opening of the enclosure cover when the circuit breaker is ON and to prevent turning the circuit breaker ON when the enclosure cover is open.
- F. NEMA 250 Type 7/9 enclosures shall be furnished with a breather and drain kit to allow their use in outdoor and wet location applications.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ENCLOSURE ENVIRONMENTAL RATING APPLICATIONS

- A. Enclosed Switches and Circuit Breakers: Provide enclosures at installed locations with the following environmental ratings.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 4. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

3.3 INSTALLATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Temporary Lifting Provisions: Remove temporary lifting of eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- E. Install fuses in fusible devices.
- F. Comply with NFPA 70 and NECA 1.

3.4 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections for Switches:
 - 1. Visual and Mechanical Inspection:
 - a. Inspect physical and mechanical condition.
 - b. Inspect anchorage, alignment, grounding, and clearances.
 - c. Verify that the unit is clean.
 - d. Verify blade alignment, blade penetration, travel stops, and mechanical operation.
 - e. Verify that fuse sizes and types match the Specifications and Drawings.
 - f. Verify that each fuse has adequate mechanical support and contact integrity.
 - g. Inspect bolted electrical connections for high resistance using one of the two following methods:
 - 1) Use a low-resistance ohmmeter.
 - a) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method in accordance with manufacturer's published data or NETA ATS Table 100.12.
 - a) Bolt-torque levels shall be in accordance with manufacturer's published data. In the absence of manufacturer's published data, use NETA ATS Table 100.12.

- h. Verify that operation and sequencing of interlocking systems is as described in the Specifications and shown on the Drawings.
- i. Verify correct phase barrier installation.
- j. Verify lubrication of moving current-carrying parts and moving and sliding surfaces.

2. Electrical Tests:

- a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter. Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- b. Measure contact resistance across each switchblade fuseholder. Drop values shall not exceed the high level of the manufacturer's published data. If manufacturer's published data are not available, investigate values that deviate from adjacent poles or similar switches by more than 50 percent of the lowest value.
- c. Perform insulation-resistance tests for one minute on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole. Apply voltage in accordance with manufacturer's published data. In the absence of manufacturer's published data, use Table 100.1 from the NETA ATS. Investigate values of insulation resistance less than those published in Table 100.1 or as recommended in manufacturer's published data.
- d. Measure fuse resistance. Investigate fuse-resistance values that deviate from each other by more than 15 percent.

C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

- 1. Test procedures used.
- 2. Include identification of each enclosed switch and circuit breaker tested and describe test results.
- 3. List deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Section 260573 "Electrical System Studies."

END OF SECTION 262816

SECTION 263213.16 - GAS-ENGINE-DRIVEN GENERATOR SETS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Engine.
2. Gas fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Load bank.
7. Outdoor generator-set enclosure.
8. Remote radiator motors.
9. Vibration isolation devices.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
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. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

C. Operation and Maintenance Data: For engine generators 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. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
 - b. Operating instructions laminated and mounted adjacent to generator location.
 - c. Training plan.

D. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Indicator Lamps: Two for every six of each type used, but no fewer than two of each.
3. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
4. Tools: Each tool listed by part number in operations and maintenance manual.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.
- B. Testing Agency Qualifications: Accredited by NETA.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.4 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Caterpillar, Inc.; Electric Power Division.
 - 2. Cummins Power Generation.
 - 3. Generac.
- B. Source Limitations: Obtain packaged engine generators and auxiliary components through one source from a single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

- A. B11 Compliance: Comply with B11.19.
- B. NFPA Compliance:
 - 1. Comply with NFPA 37.
 - 2. Comply with NFPA 70.
- C. UL Compliance: Comply with UL 2200.
- D. Engine Exhaust Emissions: Comply with EPA Tier requirements and applicable state and local government requirements. Unless otherwise amended by state and local government requirements, the following shall apply:
 - 1. Less than 75hp: Tier 4.
 - 2. 75hp – 750hp: Tier 3.
 - 3. Greater than 750hp: Tier 2.
- E. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.
- F. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: 5 to 104 deg F.

2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to 1000 feet.

2.3 ENGINE GENERATOR ASSEMBLY DESCRIPTION

- A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.
- C. Power Rating: Standby.
- D. Service Load: 350 kW, 437.5 kVA.
- E. Power Factor: 0.8, lagging.
- F. Frequency: 60 Hz.
- G. Voltage: 480 V ac.
- H. Phase: Three-phase, four wire, wye.
- I. Governor: Adjustable isochronous, with speed sensing.
- J. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
 1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
- K. Capacities and Characteristics:
 1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
 2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
- L. Engine Generator Performance for Sensitive Loads:
 1. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
 - a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
 2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
 3. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
 4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
 5. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

6. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
9. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
 - a. Provide permanent magnet excitation for power source to voltage regulator.
10. Start Time:
 - a. 10 seconds.

M. Parallel Engine Generators:

1. Automatic reactive output power control and load sharing between engine generators operated in parallel.
2. Automatic regulation, automatic connection to a common bus, and automatic synchronization, with manual controls and instruments to monitor and control paralleling functions.
3. Protective relays required for equipment and personnel safety.
4. Paralleling suppressors to protect excitation systems.
5. Reverse power protection.
6. Loss of field protection.

2.4 GAS ENGINE

- A. Fuel: Natural gas.
- B. Rated Engine Speed: 1800 rpm.
- C. Lubrication System: Engine or skid-mounted.
 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
 3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
- D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499.
- E. Integral Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.
 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
 4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
 5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - a. Rating: 50-psig maximum working pressure with coolant at 180 deg F, and noncollapsible under vacuum.
 - b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- F. Muffler/Silencer:
1. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
 - a. Minimum sound attenuation of 25 dB at 500 Hz.
 - b. Sound level measured at the property line after installation is complete shall be 65 dBA or less.
- G. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- H. Starting System: 24-V electric, with negative ground.
1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: 60 seconds.
 4. Battery: Lead acid, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice without recharging.
 5. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
 6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
 7. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
 - a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F to 140 deg F to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.

- d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
- e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
- f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.5 GAS FUEL SYSTEM

- A. Natural Gas Piping: Comply with requirements in Section 231123 "Facility Natural Gas Piping."
- B. Gas Train: Comply with NFPA 37.
- C. Engine Fuel System:
- D. Natural Gas, Vapor-Withdrawal System:
 - 1. Carburetor.
 - 2. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
 - 3. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
 - 4. Fuel Filters: One for each fuel type.
 - 5. Manual Fuel Shutoff Valves: One for each fuel type.
 - 6. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.6 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.
- B. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.
- C. Comply with UL 508A.
- D. Configuration:
 - 1. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine generator battery.
 - 2. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel. Panel shall be powered from the engine generator battery.
 - 3. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel

barriers. Panel shall be powered from the engine generator battery. Panel features shall include the following:

- a. Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6.

E. Control and Monitoring Panel:

1. Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.
 - a. Engine lubricating-oil pressure gage.
 - b. Engine-coolant temperature gage.
 - c. DC voltmeter (alternator battery charging).
 - d. Running-time meter.
 - e. AC voltmeter, for each phase.
 - f. AC ammeter, for each phase.
 - g. AC frequency meter.
 - h. Generator-voltage adjusting rheostat.
4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication, including the following:
 - a. Cranking control equipment.
 - b. Run-Off-Auto switch.
 - c. Control switch not in automatic position alarm.
 - d. Overcrank alarm.
 - e. Overcrank shutdown device.
 - f. Low water temperature alarm.
 - g. High engine temperature prealarm.
 - h. High engine temperature.
 - i. High engine temperature shutdown device.
 - j. Overspeed alarm.
 - k. Overspeed shutdown device.
 - l. Coolant low-level alarm.
 - m. Coolant low-level shutdown device.
 - n. Coolant high-temperature prealarm.
 - o. Coolant high-temperature alarm.
 - p. Coolant low-temperature alarm.
 - q. Coolant high-temperature shutdown device.
 - r. EPS supplying load indicator.
 - s. Battery high-voltage alarm.
 - t. Low cranking voltage alarm.
 - u. Battery-charger malfunction alarm.
 - v. Battery low-voltage alarm.
 - w. Lamp test.
 - x. Contacts for local and remote common alarm.
 - y. Low-starting air pressure alarm.
 - z. Low-starting hydraulic pressure alarm.
 - aa. Remote manual stop shutdown device.
 - bb. Air shutdown damper alarm when used.

- cc. Air shutdown damper shutdown device when used.
- dd. Hours of operation.
- ee. Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.
- ff. Generator overcurrent protective device not closed alarm.

F. Connection to Datalink:

- 1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.
- 2. Provide connections for datalink transmission of indications to remote data terminals via Ethernet. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

G. Common Remote Panel with Common Audible Alarm: Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

H. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

I. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices shall be coordinated to optimize selective tripping when a short circuit occurs.

- 1. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.
- 2. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Overcurrent Protective Device:

- 1. Molded-case circuit breaker, electronic-trip type; 100 percent rated; complying with UL 489:
 - a. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
 - b. Trip Settings: Selected to coordinate with generator thermal damage curve.
 - c. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
 - d. Mounting: Adjacent to or integrated with control and monitoring panel.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H.

- D. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
 - E. Enclosure: Dripproof.
 - F. Instrument Transformers: Mounted within generator enclosure.
 - G. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
 - 2. Maintain voltage within 20 percent on one step, full load.
 - 3. Provide anti-hunt provision to stabilize voltage.
 - 4. Maintain frequency within 5 percent and stabilize at rated frequency within 2 seconds.
 - H. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
 - I. Subtransient Reactance: 12 percent, maximum.
- 2.9 OUTDOOR GENERATOR-SET ENCLOSURE
- A. Description:
 - 1. Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
 - 2. Prefabricated or pre-engineered galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure, erected on concrete foundation.
 - B. Hinged Doors: With padlocking provisions.
 - C. Muffler Location: Within enclosure.
 - D. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
- 2.10 VIBRATION ISOLATION DEVICES
- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1. Material: Standard neoprene separated by steel shims.
 - B. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.
- 2.11 FINISHES
- A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.
- 2.12 SOURCE QUALITY CONTROL
- A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115.
- B. Project-Specific Equipment Tests: Before shipment, factory test engine generator and other system components and accessories manufactured specifically for this Project. Perform tests at rated load and power factor. Include the following tests:
 1. Test components and accessories furnished with installed unit that are not identical to those on tested prototype to demonstrate compatibility and reliability.
 2. Test generator, exciter, and voltage regulator as a unit.
 3. Full load run.
 4. Maximum power.
 5. Voltage regulation.
 6. Transient and steady-state governing.
 7. Single-step load pickup.
 8. Safety shutdown.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
- B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 404.
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions.
- C. Equipment Mounting:
 1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
 3. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch on 4-inch-high concrete base. Secure engine generator to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- E. Gaseous Fuel Piping:
 1. Natural gas piping, valves, and specialties for gas distribution are specified in Section 231123 "Facility Natural Gas Piping."
- F. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
- B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- C. Gaseous Fuel Connections:
 - 1. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - 2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
 - 3. Vent gas pressure regulators outside building a minimum of 60 inches from building openings.
- 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." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.
- F. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.4 IDENTIFICATION

- A. Identify system components according to Section 230553 "Identification for HVAC Piping and Equipment" and Section 260553 "Identification for Electrical Systems."
- B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency:
 - 1. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs below as specified in the NETA ATS. Certify compliance with test parameters.
 - a. Visual and Mechanical Inspection:
 - 1) Compare equipment nameplate data with drawings and specifications.
 - 2) Inspect physical and mechanical condition.
 - 3) Inspect anchorage, alignment, and grounding.
 - 4) Verify the unit is clean.
 - b. Electrical and Mechanical Tests:
 - 1) Perform insulation-resistance tests in accordance with IEEE 43.
 - a) Machines larger than 200 hp. Test duration shall be 10 minutes. Calculate polarization index.
 - b) Machines 200 hp or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

- 2) Test protective relay devices.
 - 3) Verify phase rotation, phasing, and synchronized operation as required by the application.
 - 4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
 - 5) Verify correct functioning of the governor and regulator.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here, including, but not limited to, single-step full-load pickup test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust Emissions Test: Comply with applicable government test criteria.
 7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
 8. Harmonic-Content Tests: Measure harmonic content of output voltage at 25 percent and 100 percent of rated linear load. Verify that harmonic content is within specified limits.
 9. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
 - D. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.
 - E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.
 - F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
 - G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - H. Remove and replace malfunctioning units and retest as specified above.
 - I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

- J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.6 DEMONSTRATION

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

END OF SECTION 263213.16

SECTION 263353 - STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. UPS systems.
2. Surge suppression.
3. Rectifier-charger.
4. Inverter.
5. Controls and indications.
6. Static bypass transfer switch.
7. Maintenance bypass/isolation switch.
8. Output distribution section.
9. Output isolation transformer.
10. Remote status and alarm panel.
11. Remote monitoring.
12. Battery.
13. Basic battery monitoring.
14. Additional battery monitoring.
15. Battery-cycle warranty monitoring.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For UPS.

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
4. Include diagrams for power, signal, and control wiring.

C. Operation and Maintenance Data: For UPS units to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

- A. Power Quality Specialist Qualifications: A registered professional electrical engineer or engineering technician, currently certified by the National Institute for Certification in Engineering Technologies, NICET Level 4, minimum, experienced in performance testing UPS installations and in performing power quality surveys similar to that required in "Performance Testing" Article.

B. Testing Agency Qualifications: Certified by NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 OPERATIONAL REQUIREMENTS

A. Automatic operation includes the following:

1. Double Conversion, IGBT:
 - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output. High-efficiency carrier stored trench IGBT, in both rectifier-charger and inverter circuits, provides a minimum of 97 percent efficiency for the UPS system at full load and a minimum of 94 percent efficiency at 50 percent load.
 - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to provide constant, regulated inverter power output to the load.
 - c. Power Failure: If normal power fails, the rectifier-charger and inverter use energy from the battery to supply constant, regulated power output to the load without switching or disturbance.
2. When power is restored at the normal supply terminals of the system, controls shall automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger shall supply power to the load through the inverter and simultaneously recharge the battery.
3. If the battery becomes discharged and normal supply is available, the rectifier-charger shall charge the battery. The rectifier-charger shall automatically shift to float-charge mode on reaching full charge.
4. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch shall switch the load to the normal ac supply circuit without disturbance or interruption.
5. The output power converters shall produce up to 300 percent of rated full-load current for short-circuit clearing. The inverter shall sustain steady-state overload conditions of up to 200 percent of rated full-load current for 60 seconds in normal operation.
6. The inverter shall be capable of sustaining 150 percent of system capacity for 30 seconds while powered from the battery.
7. Should overloads persist past the time limitations, the automatic static transfer switch shall switch the load to the bypass output of the UPS. When the fault has cleared, the static bypass transfer switch shall return the load to the UPS system.
8. If the battery is disconnected, the UPS shall supply power to the load from the normal supply with no degradation of its regulation of voltage and frequency of the output bus.

B. Manual operation includes the following:

1. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.

2. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.
- C. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions described below without interrupting supply to the load during switching:
1. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
 2. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
 3. Normal: Normal UPS ac supply terminals are energized and the load is supplied through the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.

2.2 PERFORMANCE REQUIREMENTS

- A. UL Compliance: Listed and labeled by an NRTL to comply with UL 1778.
- B. NFPA Compliance: UPS components shall be listed and labeled by an NRTL as suitable for installation in computer rooms according to NFPA 75.
- C. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a maximum load crest factor of 3.0, under the following conditions or combinations of the following conditions:
 1. Inverter is switched to battery source.
 2. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
 3. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
 4. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
 5. Load is 30 percent unbalanced continuously.
- D. Minimum Duration of Supply: If battery is sole energy source supplying rated full-load UPS current at 80 percent power factor, duration of supply is 30 minutes.
- E. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10 percent and minus 15 percent from nominal voltage.
- F. AC Output-Voltage Regulation for Loads 100 Percent Unbalanced: Maximum of plus or minus 2 percent over the full range of battery voltage.
- G. AC Output-Voltage Regulation for Loads 100 Percent Balanced: Maximum of plus or minus 1 percent over the full range of battery voltage.
- H. Output Frequency: 60 Hz, plus or minus 0.1 percent over the full range of input voltage, load, and battery voltage.

- I. Limitation of harmonic distortion of input current to the UPS shall be as follows:
 1. Description:
 - a. Rectifier-charger circuits shall limit THD to 5 percent, maximum, at rated full-load UPS current, for power sources with X/R ratio between 2 and 30. Provide tuned harmonic filter if required to meet harmonic distortion limit.
- J. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, 200 percent for 60 seconds in normal operation, and 150 percent for 30 seconds in battery operating mode.
- K. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 50 ms:
 1. 50 Percent: Plus or minus 3 percent.
 2. 100 Percent: Plus or minus 5 percent.
 3. Loss of AC Input Power: Plus or minus 1 percent.
 4. Restoration of AC Input Power: Plus or minus 1 percent.
- L. Input Power Factor: A minimum of 0.95 lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current without additional filters.
- M. Output Power Factor Rating: Loads with power factor of 0.9 leading to 0.8 lagging shall not require derating of the UPS. For loads with power factors outside this range, derate the UPS output as follows:
 1. Derate the UPS a maximum of 5 percent for 0.7 PF lagging.
 2. Derate the UPS a maximum of 10 percent for 0.6 PF lagging.
 3. Derate the UPS a maximum of 15 percent for 0.5 PF lagging.
 4. Derate the UPS a maximum of 20 percent for a range of 0.4 to 0.1 PF lagging.
- N. EMI Emissions: Comply with FCC rules and regulations and with 47 CFR 15 for Class A equipment.

2.3 UPS SYSTEMS

- A. Description: Self-contained, battery backup device and accessories that provides three-phase electrical power in the event of failure or sag in the normal power system.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. APC; Schneider Electric USA.
 2. Eaton.
 3. Vertiv Group Corp.
- C. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
- D. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
- E. Configuration: Multicabinet modular style units.

- F. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
- G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- H. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.
- I. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.
- J. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity: Rated phase current times a multiple of 1.73, minimum.

2.4 SURGE SUPPRESSION

- A. Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch. Protect rectifier-charger, inverter, controls, and output components.
 - 1. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 400-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.

2.5 RECTIFIER-CHARGER

- A. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
- B. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
- C. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
 - 1. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
- D. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life. The battery charger shall be matched to the battery type supplied.
- E. NiCd Battery Charger: Sense full charge by measuring the rate of temperature increase. Battery charging shall be terminated when the rate of temperature rise reaches 1.8 deg F per minute. If the battery reaches 140 deg F prior to reaching this rate of temperature rise, charging shall terminate. Chargers that determine full charge by voltage measurement to sense a 10-mV drop per cell when reaching full charge are also acceptable.

2.6 INVERTER

- A. Description:
 - 1. Pulse-width modulated, IGBT with sinusoidal output.

2. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

2.7 CONTROLS AND INDICATIONS

- A. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
- B. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
- C. Indications: Plain-language messages on a digital LCD.
 1. Quantitative indications shall include the following:
 - a. Input voltage, each phase, line to line.
 - b. Input current, each phase, line to line.
 - c. Bypass input voltage, each phase, line to line.
 - d. Bypass input frequency.
 - e. System output voltage, each phase, line to line.
 - f. System output current, each phase.
 - g. System output frequency.
 - h. DC bus voltage.
 - i. Battery current and direction (charge/discharge).
 - j. Elapsed time discharging battery.
 2. Basic status condition indications shall include the following:
 - a. Normal operation.
 - b. Load-on bypass.
 - c. Load-on battery.
 - d. Inverter off.
 - e. Alarm condition.
 3. Alarm indications shall include the following:
 - a. Bypass ac input overvoltage or undervoltage.
 - b. Bypass ac input overfrequency or underfrequency.
 - c. Bypass ac input and inverter out of synchronization.
 - d. Bypass ac input wrong-phase rotation.
 - e. Bypass ac input single-phase condition.
 - f. Bypass ac input filter fuse blown.
 - g. Internal frequency standard in use.
 - h. Battery system alarm.
 - i. Control power failure.

- j. Fan failure.
- k. UPS overload.
- l. Battery-charging control faulty.
- m. Input overvoltage or undervoltage.
- n. Input transformer overtemperature.
- o. Input circuit breaker tripped.
- p. Input wrong-phase rotation.
- q. Input single-phase condition.
- r. Approaching end of battery operation.
- s. Battery undervoltage shutdown.
- t. Maximum battery voltage.
- u. Inverter fuse blown.
- v. Inverter transformer overtemperature.
- w. Inverter overtemperature.
- x. Static bypass transfer switch overtemperature.
- y. Inverter power supply fault.
- z. Inverter transistors out of saturation.
- aa. Identification of faulty inverter section/leg.
- bb. Inverter output overvoltage or undervoltage.
- cc. UPS overload shutdown.
- dd. Inverter current sensor fault.
- ee. Inverter output contactor open.
- ff. Inverter current limit.
- 4. Controls shall include the following:
 - a. Inverter on-off.
 - b. UPS start.
 - c. Battery test.
 - d. Alarm silence/reset.
 - e. Output-voltage adjustment.
- D. Dry-form "C" contacts shall be available for remote indication of the following conditions:
 - 1. UPS on battery.
 - 2. UPS on-line.
 - 3. UPS load-on bypass.
 - 4. UPS in alarm condition.
 - 5. UPS off (maintenance bypass closed).

- E. Emergency Power off Switch: Capable of local operation and operation by means of activation by external dry contacts.

2.8 STATIC BYPASS TRANSFER SWITCH

- A. Description: Solid-state switching device providing uninterrupted transfer with a contactor or electrically operated circuit breaker to automatically provide electrical isolation for the switch.
- B. Switch Rating: Continuous duty at the rated full-load UPS current, minimum.
- C. Input SPD: 80 kA.

2.9 MAINTENANCE BYPASS/ISOLATION SWITCH

- A. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
 1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
 2. Switch shall electrically isolate other UPS components to permit safe servicing.
 3. Switch shall electrically isolate the rectifier-charger, inverter, and static bypass transfer switch from the load, but shall allow primary power to the UPS for testing.
- B. Switch Rating: Continuous duty at rated full-load UPS current.
- C. Mounting Provisions: Internal to system cabinet.

2.10 OUTPUT ISOLATION TRANSFORMER

- A. Description: Unit with low forward transfer impedance up to 3 kHz, minimum. Include the following features:
 1. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 4.
 2. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
 3. Regulation: 5 percent, maximum, at rated nonlinear load current.
 4. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
 5. Electrostatic Shielding of Windings: Independent for each winding.
 6. Coil Leads: Physically arranged for minimum interlead capacitance.
 7. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
 8. Capacitive Coupling between Primary and Secondary: 33 pF, maximum, over a frequency range of 20 Hz to 1 MHz.

2.11 REMOTE STATUS AND ALARM PANEL

- A. Description: Labeled LEDs on panel faceplate indicating five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
 1. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.

2.12 REMOTE MONITORING

- A. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
1. Connectors and network interface units for data transmission via RS-485, Ethernet, or web-based link.
 2. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
 3. Software and Hardware: Compatible with that specified in Section 260913 "Electrical Power Monitoring and Control."

2.13 BATTERY

- A. Description:
1. Valve-regulated, heavy-duty, industrial, recombinant, pocket plate design, NiCd units in polypropylene containers, complete with battery disconnect switch and intercell connectors.
 - a. Factory assembled in an isolated compartment of UPS cabinet.
 - b. Mount on multi-tier, painted steel racks.
 - c. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.
 2. Lithium-Ion batteries will be considered during the submittal process.

2.14 BASIC BATTERY MONITORING

- A. Description: Continuous, real-time capture of battery performance data.
- B. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
- C. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 167 deg F occurs within the compartment.
- D. Annunciation of Alarms: At UPS control panel and remotely.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for conditions affecting performance of the UPS.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Verify installation conditions are representative of the conditions used in the coordination studies for the electrical system. Provide fuse protection according to Section 262813 "Fuses" if required for coordination with UPS overcurrent protective device requirements.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
 - 1. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
 - 2. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- D. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base 6 inches from the outer edge of the base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- E. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- F. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated. Apply oxide inhibitor on battery terminals.

3.3 GROUNDING

- A. Separately Derived Systems:
 - 1. If part of a listed power supply for a data-processing room, comply with manufacturer's written instructions that include grounding requirements in excess of NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify each battery cell individually.

3.5 BATTERY EQUALIZATION

- A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.

3.6 FIELD QUALITY CONTROL

A. Administrant for Tests and Inspections:

1. Administer and perform tests and inspections.

B. Tests and Inspections:

1. Inspect interiors of enclosures, including the following:
 - a. Inspect anchorage, alignment, grounding, and required clearances.
 - b. Component type and labeling verification.
 - c. Ratings of installed components.
2. Test electrical and mechanical interlock systems for correct operation and sequencing.
3. Inspect bolted electrical connections for high resistance using one or more of the following methods:
 - a. Use of low-resistance ohmmeter according to Section 7.22.2.2 of NETA ATS.
 - b. Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data or Table 100.12 of NETA ATS.
 - c. Perform thermographic survey according to Section 9 of NETA ATS.
4. Test static transfer from inverter to bypass and back. Use normal load, if possible.
5. Test dc undervoltage trip level on inverter input breaker. Set according to manufacturer's published data.
6. Verify synchronizing indicators for static switch and bypass switches.
7. Test automatic transfer switches.
 - a. Perform resistance measurements through bolted connections with a low-resistance ohmmeter, if applicable, according to Section 7.22.3.1 of NETA ATS.
 - b. Perform insulation-resistance tests on all control wiring for ground. Applied potential shall be 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable. Test duration shall be one minute. For units with solid-state components or for control devices that cannot tolerate the applied voltage, follow manufacturer's recommendation.
 - c. Perform a contact/pole-resistance test.
 - d. Verify settings and operation of control devices.
 - e. Calibrate and set all relays and timers according to Section 7.9 of NETA ATS.
 - f. Verify phase rotation, phasing, and synchronized operation as required by the application.
 - g. Perform automatic transfer tests.
 - 1) Simulate loss of normal power.
 - 2) Return to normal power.
 - 3) Simulate loss of emergency power.
 - 4) Simulate all forms of single-phase conditions.

- h. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Time delay on transfer.
 - 3) Alternative source voltage-sensing and frequency-sensing relays.
 - 4) Automatic transfer operation.
 - 5) Interlocks and limit switch function.
 - 6) Time delay and retransfer on normal power restoration.
- 8. Test direct current system's batteries.
 - a. Verify adequacy of battery support racks, mounting, anchorage, alignment, grounding, and clearances.
 - b. Inspect spill containment installation. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - c. Verify all charger functions and alarms.
 - d. Measure each cell voltage and total battery voltage with charger energized and in float mode of operation.
 - e. Perform a load test according to manufacturer's published data or IEEE 450.
 - f. Measure charger float and equalizing voltage levels. Adjust to battery manufacturer's recommended settings.
 - g. Test values.
 - 1) Compare bolted connection resistance values to values of similar connections. Investigate values that deviate from those of similar bolted connections by more than 50 percent of the lowest value.
 - 2) Charger float and equalize voltage levels shall be according to battery manufacturer's published data.
 - 3) The results of charger functions and alarms shall be according to manufacturer's published data.
 - 4) Cell voltages shall be within 0.05 V of each other or according to manufacturer's published data.
 - 5) Cell internal ohmic values (resistance, impedance, or conductance) shall not vary by more than 25 percent between identical cells that are in a fully charged state.
 - 6) Results of load tests shall be according to manufacturer's published data or IEEE 450.
- 9. Test communication of status and alarms to remote monitoring equipment.
- C. The UPS system will be considered defective if it does not pass tests and inspections.
- D. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
- E. Prepare test and inspection reports.

3.7 DEMONSTRATION

- A. TrainOwner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 263353

SECTION 263600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Contactor-type automatic transfer switches.
 - 2. Nonautomatic transfer switches.
 - 3. Transfer switch accessories.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
 - 2. Include material lists for each switch specified.
 - 3. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
 - 4. Riser Diagram: Show interconnection wiring between transfer switches, bypass/isolation switches, annunciators, and control panels.
- C. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Features and operating sequences, both automatic and manual.
 - b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.3 QUALITY ASSURANCE

- A. Testing Agency Qualifications:
 - 1. Member company of NETA.
 - a. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.4 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two (2) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with UL 1008 unless requirements of these Specifications are stricter.
- D. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Short-time withstand capability for three cycles.
- E. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- F. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- G. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.
- H. Neutral Switching: Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- I. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
- J. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed markers at terminations. Color-coding and wire and cable markers are specified in Section 260553 "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
 - 4. Accessible via front access.
- K. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.2 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ABB, Electrification Business.
 - 2. Caterpillar, Inc.; Electric Power Division.

3. Cummins Power Generation.
 4. Eaton.
 5. Generac.
 6. Hubbell Utility Solutions; Hubbell Incorporated.
 7. Russelectric, Inc.
 8. Vertiv; Vertiv Holdings Co.
- B. Comply with Level 1 equipment according to NFPA 110.
- C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are unacceptable.
 2. Switch Action: Double throw; mechanically held in both directions.
 3. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
 4. Conductor Connectors: Suitable for use with conductor material and sizes.
 5. Material: Hard-drawn copper, 98 percent conductivity.
 6. Main and Neutral Lugs: Compression type.
 7. Ground Lugs and Bus-Configured Terminators: Compression type.
 8. Ground bar.
 9. Connectors shall be marked for conductor size and type according to UL 1008.
- D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.
1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.
 2. Fully automatic break-before-make operation with center off position.
- E. Electric Nonautomatic Switch Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- F. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
- G. Automatic Transfer-Switch Controller Features:
1. Controller operates through a period of loss of control power.
 2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at

90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.

4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts:
 - a. Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.

2.3 NONAUTOMATIC TRANSFER SWITCHES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. ASCO Power Technologies.
 2. Caterpillar, Inc.; Electric Power Division.
 3. Cummins Power Generation.
 4. ESL Power Systems, Inc.
 5. Eaton.
 6. Russelectric, Inc.
- B. Electrically Operated: Electrically actuated by push buttons designated "Normal Source" and "Alternative Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- C. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
- D. Pilot Lights: Indicate source to which load is connected.

- E. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternative-source sensing circuits.
 - 1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - 2. Emergency Power Supervision: Red light with nameplate engraved "Alternative Source Available."
- F. Unassigned Auxiliary Contacts: Switch shall have one set of normally closed contacts for each switch position, rated 10 A at 240-V ac.
- G. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Switch Action: Double throw; mechanically held in both directions.
 - 2. Contacts: Silver composition or silver alloy for load-current switching.
 - 3. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 4. Material: Tin-plated aluminum.
 - 5. Main and Neutral Lugs: Mechanical type.
 - 6. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 - 7. Ground bar.
 - 8. Connectors shall be marked for conductor size and type according to UL 1008.

2.4 TRANSFER SWITCH ACCESSORIES

- A. Bypass/Isolation Switches:
 - 1. Source Limitations: Same manufacturer as transfer switch in which installed.
 - 2. Comply with requirements for Level 1 equipment according to NFPA 110.
 - 3. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
 - a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. Interlocks shall prevent transfer-switch operation, except for testing or maintenance, while automatic transfer switch is isolated.
 - b. Provide means to make power available to transfer-switch control circuit for testing and maintenance purposes.
 - c. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations. Transfer switch and bypass/isolation switch shall be in isolated compartments.
 - d. Transition:
 - 1) Provide closed-transition operation when transferring from main transfer switch to bypass/isolation switch on the same power source.

- e. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
 - f. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
 - g. Automatic and Nonautomatic Control: Automatic transfer-switch controller shall also control the bypass/isolation switch.
 - h. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
 - i. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
4. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.
- B. Remote Annunciator and Control System:
- 1. Source Limitations: Same manufacturer as transfer switch in which installed.
 - 2. Include the following functions for indicated transfer switches:
 - a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
 - b. Indication of switch position.
 - c. Indication of switch in test mode.
 - d. Indication of failure of digital communication link.
 - e. Key-switch or user-code access to control functions of panel.
 - f. Control of switch-test initiation.
 - g. Control of switch operation in either direction.
 - h. Control of time-delay bypass for transfer to normal source.
 - 3. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically shall revert to standalone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
 - 4. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
 - a. Controls and indicating lights grouped together for each transfer switch.
 - b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
 - c. Digital Communication Capability: Matched to that of transfer switches supervised.
 - d. Mounting: Flush, modular, steel cabinet unless otherwise indicated.

2.5 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.
- B. Prepare test and inspection reports.
 - 1. For each of the tests required by UL 1008, performed on representative devices, for emergency and/or legally required systems as appropriate for the system type. Include results of test for the following conditions:
 - a. Overvoltage.
 - b. Undervoltage.
 - c. Loss of supply voltage.
 - d. Reduction of supply voltage.
 - e. Alternative supply voltage or frequency is at minimum acceptable values.
 - f. Temperature rise.
 - g. Dielectric voltage-withstand; before and after short-circuit test.
 - h. Overload.
 - i. Contact opening.
 - j. Endurance.
 - k. Short circuit.
 - l. Short-time current capability.
 - m. Receptacle withstand capability.
 - n. Insulating base and supports damage.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Floor-Mounting Switch: Anchor to floor by bolting.
 - 1. Install transfer switches on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.
 - 3. Provide workspace and clearances required by NFPA 70.
- B. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.
- C. Identify components according to Section 260553 "Identification for Electrical Systems."
- D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.
- E. Comply with NECA 1.

3.2 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- E. Connect twisted pair cable according to Section 271513 "Communications Copper Horizontal Cabling."
- F. Route and brace conductors according to manufacturer's written instructions and Section 260529 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.
- G. Final connections to equipment shall be made with liquidtight, flexible metallic conduit no more than 18 inches in length.

3.3 FIELD QUALITY CONTROL

- A. Adminstrant for Tests and Inspections:
 - 1. Administer and perform tests and inspections.
- B. Tests and Inspections:
 - 1. After installing equipment, test for compliance with requirements according to NETA ATS.
 - 2. Visual and Mechanical Inspection:
 - a. Compare equipment nameplate data with Drawings and Specifications.
 - b. Inspect physical and mechanical condition.
 - c. Inspect anchorage, alignment, grounding, and required clearances.
 - d. Verify that the unit is clean.
 - e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.
 - f. Verify that manual transfer warnings are attached and visible.
 - g. Verify tightness of all control connections.
 - h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:
 - 1) Use of low-resistance ohmmeter.
 - 2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
 - i. Perform manual transfer operation.

- j. Verify positive mechanical interlocking between normal and alternate sources.
 - k. Perform visual and mechanical inspection of surge arresters.
 - l. Inspect control power transformers.
 - 1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
 - 2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
 - 3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.
3. Electrical Tests:
- a. Perform insulation-resistance tests on all control wiring with respect to ground.
 - b. Perform a contact/pole-resistance test. Compare measured values with manufacturer's acceptable values.
 - c. Verify settings and operation of control devices.
 - d. Calibrate and set all relays and timers.
 - e. Verify phase rotation, phasing, and synchronized operation.
 - f. Perform automatic transfer tests.
 - g. Verify correct operation and timing of the following functions:
 - 1) Normal source voltage-sensing and frequency-sensing relays.
 - 2) Engine start sequence.
 - 3) Time delay on transfer.
 - 4) Alternative source voltage-sensing and frequency-sensing relays.
 - 5) Automatic transfer operation.
 - 6) Interlocks and limit switch function.
 - 7) Time delay and retransfer on normal power restoration.
 - 8) Engine cool-down and shutdown feature.
4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
- a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
5. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

- a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- C. Coordinate tests with tests of generator and run them concurrently.
 - D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
 - E. Transfer switches will be considered defective if they do not pass tests and inspections.
 - F. Remove and replace malfunctioning units and retest as specified above.
 - G. Prepare test and inspection reports.
- 3.4 DEMONSTRATION
- A. Train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.
 - B. Coordinate this training with that for generator equipment.
- END OF SECTION 263600

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes lightning protection system for ordinary structures.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings:
 - 1. Include layouts of the lightning protection system, with details of the components to be used in the installation.
 - 2. Include raceway locations needed for the installation of conductors.
 - 3. Details of air terminals, ground rods, ground rings, conductor supports, splices, and terminations, including concealment requirements.
 - 4. Include roof attachment details, coordinated with roof installation.
 - 5. Calculations required by NFPA 780 for bonding of metal bodies.
- C. Coordination Drawings: Lightning protection system Shop Drawings, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Lightning protection cabling attachments to roofing systems and accessories.
 - 2. Lightning protection strike termination device attachment to roofing systems, coordinated with the roofing system manufacturer.
 - 3. Lightning protection system components penetrating roofing and moisture protection systems and system components, coordinated with the roofing system manufacturer.
- D. Maintenance Data: For lightning protection system to include in maintenance manuals.
 - 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Dimensioned site plan showing dimensioned route of the ground loop conductor and the ground rod locations. Comply with requirements of Section 017839 "Project Record Documents."
 - b. A system testing and inspection record, listing the results of inspections and ground resistance tests, as recommended by NFPA 780, Annex D.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: UL-listed installer, category OWAY.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. ERICO; brand of nVent Electrical plc.
 2. East Coast Lightning Equipment Inc.
 3. Harger Lightning & Grounding; business of Harger, Inc.
 4. Heary Bros. Lightning Protection Co. Inc.
 5. Independent Protection Co.
 6. National Lightning Protection.
 7. Preferred Lightning Protection.
 8. Robbins Lightning, Inc.
 9. Thompson Lightning Protection, Inc.
 10. VFC Lightning Protection.
 11. allG Fabrication (formerly ALT).

2.2 PERFORMANCE REQUIREMENTS

- A. NFPA Lightning Protection Standard: Comply with NFPA 780 requirements for Class I buildings.

2.3 MATERIALS

- A. Air Terminals:
1. Copper or Aluminum unless otherwise indicated.
 2. 1/2-inch diameter by 12 inches long.
 3. Rounded tip.
 4. Integral base support.
- B. Class 1 Main Conductors:
1. Stranded Copper: 57,400 circular mils in diameter.
 2. Aluminum: 98,600 circular mils in diameter.
- C. Secondary Conductors:
1. Stranded Copper: 26,240 circular mils in diameter.
 2. Aluminum: 41,400 circular mils in diameter.
- D. Ground Rods:
1. Material: Solid copper.
 2. Diameter: 5/8 inch.
 3. Rods shall be not less than 120 inches long.

- E. Conductor Splices and Connectors: Compression fittings that are installed with hydraulically operated tools, or exothermic welds, approved for use with the class type.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install lightning protection components and systems according to NFPA 780.
- B. Install conductors with direct paths from air terminals to ground connections. Avoid bends less than 90 degrees and 8 inches in radius and narrow loops.
- C. Conceal conductors within normal view from exterior locations at grade within 200 feet of building. Comply with requirements for concealed systems in NFPA 780.
 - 1. Roof penetrations required for down conductors and connections to structural-steel framework shall be made using listed through-roof fitting and connector assemblies with solid rods and appropriate roof flashings. Use materials approved by the roofing manufacturer for the purpose. Conform to the methods and materials required at roofing penetrations of the lightning protection components to ensure compatibility with the roofing specifications and warranty.
 - 2. Install conduit where necessary to comply with conductor concealment requirements.
 - 3. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.
- D. Ground Ring Electrode: The conductor shall be not less than the main-size lightning conductor.

3.2 CONNECTIONS

- A. Aboveground concealed connections, and connections in earth or concrete, shall be done by exothermic welds or by high-compression fittings listed for the purpose.
- B. Aboveground exposed connections shall be done using the following types of connectors, listed and labeled for the purpose: bolted connectors.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.

3.3 CORROSION PROTECTION

- A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

- B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

- A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
 - 1. Perform inspections as required to obtain a UL Master Label for system.
- B. Prepare test and inspection reports and certificates.

END OF SECTION 264113

SECTION 265119 - LED INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Materials.
 - 2. Luminaire support.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.3 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications:
 - 1. Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
 - 2. Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.5 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within standard warranty period.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance:

1. Luminaires shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
2. Luminaires and lamps shall be labeled vibration and shock resistant.

B. Ambient Temperature: 41 to 104 deg F.

1. Relative Humidity: Zero to 95 percent.

C. Altitude: Sea level to 1000 feet.

2.2 LUMINAIRE REQUIREMENTS

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI.

C. Recessed luminaires shall comply with NEMA LE 4.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Steel:

1. ASTM A36/A36M for carbon structural steel.
2. ASTM A568/A568M for sheet steel.

C. Stainless Steel:

1. Manufacturer's standard grade.

2. Manufacturer's standard type, ASTM A240/240M.

D. Galvanized Steel: ASTM A653/A653M.

E. Aluminum: ASTM B209.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE SUPPORT

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Wires: ASTM A641/A641M, Class 3, soft temper, zinc-coated steel, 12 gage.

D. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.

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

3.2 TEMPORARY LIGHTING

A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

A. Comply with NECA 1.

- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaires:
 - 1. Secured to outlet box.
 - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
 - 3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaires:
 - 1. Attached to a minimum 20 gauge backing plate attached to wall structural members.
 - 2. Do not attach luminaires directly to gypsum board.
- G. Suspended Luminaires:
 - 1. Ceiling Mount: Minimum two 5/32-inch- diameter aircraft cable supports adjustable to 10 feet in length.
 - 2. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 - 3. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 - 4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- H. Ceiling-Grid-Mounted Luminaires:
 - 1. Secure to any required outlet box.
 - 2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
 - 3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.
- I. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 265119

SECTION 265613 - LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Poles and accessories for support of luminaires.

1.2 SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.
4. Anchor bolt templates keyed to specific poles and certified by manufacturer.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B660.

B. Store poles on decay-resistant skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design pole foundation and pole power system.
- B. Seismic Performance: Foundation and pole shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- C. Structural Characteristics: Comply with AASHTO LTS-6-M.

- D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.
- E. Live Load: Single load of 500 lbf distributed according to AASHTO LTS-6-M.
- F. Ice Load: Load of 3 lbf/sq. ft., applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.
- G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.
 - 1. Basic wind speed for calculating wind load for poles 50 feet high or less is 100 mph.
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 25 years.
 - c. Velocity Conversion Factor: 1.0.
- H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of 1.1 to obtain the EPA to be used in pole selection strength analysis.
- I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

- A. <Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. [American LitePole.](#)
 - 2. [Appleton; Emerson Electric Co., Automation Solutions.](#)
 - 3. [Bridgewell Resources.](#)
 - 4. [Cooper Lighting Solutions; Signify North America Corp.](#)
 - 5. [E-conolight.](#)
 - 6. [H.E. Williams.](#)
 - 7. [Hapco.](#)
 - 8. [Hubbell Electrical Solutions; Hubbell Incorporated.](#)
 - 9. [Kim Lighting; brand of GE Current, a Daintree company; American Industrial Partners \(AIP\).](#)
 - 10. [LSI Industries.](#)
 - 11. [Lithonia Lighting; Acuity Brands Lighting, Inc.](#)
 - 12. [Millerbernd Manufacturing Company.](#)
 - 13. [NAFCO; brand of Wisconsin Lighting Lab, Inc.](#)
 - 14. [Ruud Lighting; brand of Cree Lighting; subsidiary of Ideal Industries, Inc.](#)
 - 15. [Union Metal Industries Corp.](#)
- B. Source Limitations: Obtain poles from single manufacturer or producer. Where possible, pole and light fixture shall be from the same manufacturer.
- C. Poles: Comply with ASTM A500/A500M, Grade B carbon steel with a minimum yield of 46,000 psig; one-piece construction up to 40 feet in height with access handhole in pole wall.

1. Shape: Square, straight.
 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- D. Grounding and Bonding Lugs: Welded 1/2-inch 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 indicated, and accessible through handhole.
- E. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.
- F. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 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 selected by Architect from manufacturer's full range.

2.3 MOUNTING HARDWARE

- A. Anchor Bolts: Manufactured to ASTM F1554, Grade 55, with a minimum yield strength of 55,000 psi.
1. Type, size, and threading per manufacturer's instructions.
- B. Nuts: ASTM A563, Grade A, Heavy-Hex.
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
 2. Two nuts provided per anchor bolt.
- C. Washers: ASTM F436, Type 1.
1. Galvanizing: Hot dip galvanized according to ASTM A153, Class C.
 2. One washer(s) provided per anchor bolt.

2.4 GENERAL FINISH REQUIREMENTS

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

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.
- C. Examine roughing-in for foundation and conduit to verify actual locations of installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 POLE FOUNDATION

- A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A36/A36M and hot-dip galvanized according to ASTM A123/A123M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

3.3 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.
 - 1. Fire Hydrants and Water Piping: 60 inches.
 - 2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet.
 - 3. Trees: 15 feet from tree trunk.
- C. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level according to pole manufacturer's written instructions.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers unless otherwise indicated.
 - 4. Use a short piece of 1/2 -inch diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- D. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch-wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete

slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch below top of concrete slab.

- E. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 GROUNDING

- A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

END OF SECTION 265613

SECTION 265619 - LED EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Luminaire types.
 - 2. Materials.
 - 3. Finishes.
 - 4. Luminaire support components.

1.2 SUBMITTALS

- A. Product Data: For each type of product.
- B. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.
 - 1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.

1.3 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications:
 - 1. Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
 - 2. Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.5 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance:
 - 1. Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 2. Luminaires and lamps shall be labeled vibration and shock resistant.

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: Comply with UL 1598 and listed for wet location.
- C. Internal driver.
- D. Source Limitations:
 - 1. Obtain luminaires from single source from a single manufacturer.

2.3 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Epoxy-coated steel. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 - 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:
 - 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
 - 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 - 1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.4 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- C. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.
 - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color:
 - 1) As selected by Architect from manufacturer's full range.

2.5 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, and canopy ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- E. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- F. Wall-Mounted Luminaire Support:
 - 1. Attached to a minimum 1/8 inch backing plate attached to wall structural members.

- G. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated.
- I. Coordinate layout and installation of luminaires with other construction.
- J. Adjust luminaires that require field adjustment or aiming.
- K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and Section 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTED LUMINAIRES

- A. Aim as indicated on Drawings.
- B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Notify engineer of average levels measured at no less than 10 locations.

2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.
 - E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 265619

SECTION 270010 - SUPPLEMENTAL REQUIREMENTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Supplemental requirements generally applicable to the Work specified in Division 27.

B. Related Requirements:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01, Division 07, Division 08, and Division 26 Specification Sections, apply to this Section.

C. Definitions for Communications:

1. Remote Office Phone System (ROPS): VoIP system that allows phones for a business or organization located anywhere in the world with internet connectivity to behave similar to phones connected to a PBX.
2. Voice over Internet Protocol (VoIP): Digital telephone packet technology that uses the internet for its transmission medium.

1.2 SCOPE OF WORK

- A. The Communications Scope of Work (the Work) is generally described by these Specifications and the Drawings numbered with Prefixes T, TG, and TS, but the Work also includes all such work indicated in **all** of the Contract Documents, including, but not limited to: Instructions to Bidders; Proposal Form; General Conditions; Supplementary General Conditions; Architectural, Interiors, Equipment, Kitchen, Structural, Mechanical, Electrical, and Plumbing Drawings and Specifications; and all Addenda.

- B. The Work shall include providing a complete, functional system, including each element of the system as specified, indicated, or reasonably inferred by the Drawings or these Specifications. Provide every article, device, or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the Scope of Work include, but are not limited to, materials, labor, supervision, supplies, tools, equipment, transportation, and utilities.

- C. Drawings are graphic representations of the Work. They show the materials and their relationship to one another, including sizes, shapes, locations, and connections, and the general arrangement of equipment, fixtures, outlets, and circuits. The Drawings may not show exact details about elevations, offsets, control lines, and installation requirements. Use the Drawings as a guide when laying out the Scope of Work to ensure materials and equipment will fit into the designated spaces and will result in a complete, coordinated, and properly operating system when installed per the manufacturer's instructions.

1.3 CODES, REFERENCES, AND STANDARDS

- A. The Work shall comply at a minimum with National Fire Protection Association (NFPA) codes, state and local building codes, and all other applicable codes and ordinances in force, including performance, workmanship, equipment, and materials. Where conflicts between the various codes, ordinances, rules, and regulations exist, comply with the most stringent. Wherever requirements of the Contract Documents exceed those of the above items, the Contract Documents shall govern.
- B. Code compliance, at a minimum, is mandatory. Construe nothing in the Construction Documents as permitting work without compliance with Code. Bring all conflicts observed between Code and the Contract Documents to the Architect's and Engineer's attention immediately. Contractor will be held responsible for any violation of the law.
- C. Obtain inspections by the authorities having jurisdiction. Upon completion of the Work, obtain and deliver to the Owner executed final certificates of acceptance from the authorities having jurisdiction.
- D. Comply with rules and regulations of public utilities and municipal departments affected by the connection of services.
- E. Perform all communications work in compliance with applicable safety regulations, including OSHA regulations. Provide all safety lights, guards, and warning signs required for the performance of the communications work.
- F. Obtain and pay for all permits, licenses, and fees that are required by the governing authorities for the performance of the communications work.

1.4 COORDINATION

- A. Interruption of Existing Telephone Service: Do not interrupt telephone service to facilities occupied by Owner or others unless permitted under the following conditions:
 - 1. Notify Owner no fewer than seven days in advance of proposed interruption of telephone service.
 - 2. Do not proceed with interruption of telephone service without Owner's written permission.
- B. Coordinate layout of work with other trades. Location of Telecom outlets are approximate on drawings. Install adjacent to nearest associated receptacle. Make minor adjustments in location required for coordination. Submit adjustments to the General Contractor or Construction Manager for approval before proceeding with the work.
- C. Coordination with Structural, HVAC, and Plumbing systems:
 - 1. Systems will take precedence over locations of conduit lines where conflict occurs
 - 2. Systems will not interfere with or impede the routing and clearances of cable tray, raceways, or other pathways dedicated to communications.
 - 3. All potential issues shall be brought to the attention of the General Contractor or Construction Manager immediately.
- D. Coordinate Firestopping applications with Division 07 and Division 26.

- E. Coordinate location of access panels and doors that are concealed by finished surfaces or other methods. Access doors and panels are specified in Division 08.

1.5 PREINSTALLATION MEETINGS

- A. Communications Preconstruction Conference: Schedule conference with Architect and Owner not later than 30 days after notice to proceed. Must be scheduled at the same time as Electrical Preconstruction. Agenda topics include, but are not limited to, the following:
 1. Installation schedule for communications systems.
 2. Value analysis proposals and requests for substitution of communications equipment.
 3. Utility services work coordination and monitoring service requests.
 4. Commissioning activities.

1.6 SUBMITTALS

- A. Refer to Division 1 and the General Provisions of the Contract for exact submittal procedures
- B. Submit for approval, manufacturers' technical literature, shop and construction drawings and other submittals required by the Specification. These documents shall be provided prior to ordering equipment and executing any related work on site.
- C. Product Data: Submit for approval detailed product data such as model number, all relevant ratings, country of origin, interface details as necessary, covers and main supports. A specifications compliance sheet shall be provided for each product indicating if the proposed product comply/does not comply with each article of the related specification section.
 1. At each paragraph of the specification indicate in the left-hand margin if the paragraph "NA" not applicable, "C" complies, or "E" exception. Explain fully any exceptions to the paragraphs.
 2. Where applicable, the compliance sheet may include a supplier/manufacture description of how a certain product might achieve compliance with an alternative method as opposed to the method provided in the specifications.
- D. Shop and Construction Drawings:
 1. Dimensioned plans and sections or elevation layouts of electrical equipment, as applicable.
 2. Shop and construction drawings must demonstrate that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings shall clearly state the name and location of the work the names of the Engineer and Contractor, submission date, cross-references to the drawings and specification and the specific reference number, location, service, and function of each item.
 3. Drawings shall include but not be limited to the following:
 - a. Details of communication installations in conjunction with all trades concerned, showing sleeves and openings for floors.
 - b. Composite construction drawings fully dimensioned showing locations of cables, conduits, cable trays, shafts, ceiling spaces and all other critical locations.

- c. Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.
 - 4. One-Line Diagrams:
 - a. Service and Bonding backbone riser diagram clearly indicating all equipment ratings, frame sizes, cable sizes, nomenclature/identification number shall be submitted for the Engineer's approval.
 - b. Signal Flow clearly indicating all equipment ratings and nomenclature/identification number for all audio visual systems shall be submitted for the Engineer's approval.
 - 5. System Schematics
 - 6. Specification Sheets for Test Equipment
 - 7. Bill of Materials
 - 8. Contracting Firm, Installation Team, and Current Manufacturer Qualifications and Certifications
- E. Provide throughout installation:
 - 1. Material samples, if requested by the Architect, Low Voltage Designer, General Contractor or Construction Manager.
 - 2. Periodic field quality control reports.
 - 3. Periodic cable test and certification reports. At minimum at completion of each phase or area. Provide summary hard copy or full test results on compact disc or USB drive when requested by the General Contractor, Construction Manager, OWNER, or Low Voltage Designer.
- F. Provide prior to completion:
 - 1. Component labeling scheme to be applied to cabling components must be approved by the Architect, Low Voltage Designer, General Contractor, or Construction Manager.
 - 2. Draft Cable administration drawings, to assist OWNER in the planning process, typed, PDF format.
- G. Provide after installation is complete:
 - 1. One (1) full size set of record drawings of the actual installation for the Division 27 Systems as D or E size originals in AutoCAD and PDF format.
 - 2. Provide three (3) bound sets of Operating and Maintenance Manuals formatted as defined by Division 1 and within Section 27 00 00. Each copy should include:
 - a. Copies of Approved Submittals.
 - b. Cable Test Results documented electronically. Handwritten test reports will be rejected.
 - c. Instruction Manuals including equipment and cable schedules, operating instructions, and manufacturer instructions.
 - d. Manufacturer's Warranty Certificate.
 - e. Warranty Contacts names and phone numbers (office and mobile)

1.7 QUALITY ASSURANCE

- A. Execute the Work in a thorough and professional manner by competent and experienced workmen duly trained to perform the Work.

- B. Install all the Work per the manufacturer's requirements, recommendations, and installation instructions, unless the Contract Documents exceed those requirements. Install all equipment and materials in a neat and professional manner—aligned, leveled, and adjusted for satisfactory operation—in accordance with NECA standards.
- C. Unless indicated otherwise in the Contract Documents, provide new equipment and materials of the best quality and design, free from defects and imperfections, and with markings or a nameplate identifying the manufacturer. Provide all equipment and materials of the same type from the same manufacturer whenever practicable.

1.8 QUALIFICATIONS

- A. Qualified Regional Manufacturer: Manufacturer, possessing qualifications specified in Section 014000 "Quality Requirements," that maintains a service center capable of providing training, parts, and emergency on-site repairs to Project site with response time less than eight hours.
- B. Structural Professional Engineer: Professional engineer possessing active qualifications specified in Section 014000 "Quality Requirements," with expertise in structural engineering, including seismic- and wind-load modeling and analysis.
- C. Communications Design Professional: Design professional possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
 - 1. Expertise in design of communications infrastructure and distribution equipment.
- D. Welder: Installer possessing active qualifications specified in Section 014000 "Quality Requirements," with training and certification in accordance with American Welding Society (AWS).
- E. Communications Cable Installer: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" and the following:
 - 1. Training and manufacturer certification to install, splice, and terminate communications cabling.
 - 2. Installation Supervisor: BICSI Technician (TECH) certification.
 - 3. Copper Installers: 30 percent of employees possess BICSI Copper Installer 2 (INSTC) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
 - 4. Fiber Installers: 30 percent of employees possess BICSI Optical Fiber Installer 2 (INSTF) certification. Remaining employees possess BICSI Installer 1 (INST1) certification.
- F. Communications Testing Agency: Entity possessing active credentials from a qualified electrical testing laboratory recognized by authorities having jurisdiction.
 - 1. On-site communications testing supervisor must have BICSI Technician (TECH) certification and documented training, and be experienced with testing communications equipment in accordance with TIA testing standards.

- G. Structural Testing and Inspecting Agency: Entity possessing active qualifications specified in Section 014000 "Quality Requirements" with documented training and experience with testing structural concrete, seismic controls, and wind-load controls.

PART 2 - PRODUCTS

2.1 SUBSTITUTION LIMITATIONS FOR COMMUNICATIONS EQUIPMENT

- A. Substitution requests for communications equipment will be entertained under the following conditions:
 - 1. Substitution requests may be submitted for consideration prior to the Communications 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. Contractor is responsible for sequencing and scheduling equipment procurement. After the Communications Preconstruction Conference, insufficient lead time for equipment delivery will not be considered a valid reason for substitution.

2.2 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 EXAMINATION

- A. Verification of Conditions:
 - 1. Examine all elements intended for Communications. Check pathways and other elements for compliance with space allocations, installation tolerances, installation hazards or impediments, and other conditions affecting installation.
 - 2. Contractor to perform field survey and take measurements of footages for cabling and materials shown on Project Drawings prior to ordering materials. Project Drawings are based upon Architectural Drawings and Engineer's route and pathway assumptions.

3.2 INSTALLATION OF COMMUNICATIONS WORK

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' instructions, comply with NFPA 70, NECA NEIS 1, and BICSI N1 for installation of Work specified in Division 27. Consult Architect for resolution of conflicting requirements.

3.3 FIELD QUALITY CONTROL

A. Administrant for Communications Tests and Inspections:

1. Owner will engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified communications testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

B. Administrant for Structural Tests and Inspections:

1. Owner will engage qualified structural testing and inspecting agency to administer and perform tests and inspections.
2. Engage qualified structural testing and inspecting agency to administer and perform tests and inspections.
3. Engage factory-authorized service representative to administer and perform tests and inspections on components, assemblies, and equipment installations, including connections.
4. Administer and perform tests and inspections with assistance of factory-authorized service representative.

3.4 CLOSEOUT ACTIVITIES

A. Demonstration:

1. With assistance from factory-authorized service representatives, demonstrate to Owner's maintenance and clerical personnel and building occupants how to operate the following systems and equipment:
 - a. Audio Visual equipment specified in Section 274100 "Audiovisual Systems."
2. Allow Owner to record demonstrations.

B. Training:

1. With assistance from factory-authorized service representatives, train Owner's maintenance personnel on the following topics:
 - a. How to adjust, operate, and maintain MATV equipment specified in Section 274133 "Master Antenna Television System."
 - b. How to adjust, operate, and maintain Audiovisual system equipment specified in Section 274100 "AudioVisual System."
 - c. How to adjust, operate, and maintain public address system equipment specified in Section 275116 "Public Address System."

2. Allow Owner to record training sessions.

END OF SECTION 270010

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Installation of communications busbars.
2. Selection and installation of communications bonding conductors.
3. Selection of signal reference grids.
4. Installation of grounding and bonding for towers and antennas.

1.2 DEFINITIONS

- A. BBC: Backbone bonding conductor, for connecting multiple TBBs serving the same floor.
- B. PBB: Primary bonding busbar, located in main distribution frame room, ideally near electrical service entrance.
- C. RBB: Rack bonding busbar, located in equipment cabinets and racks.
- D. SBB: Secondary bonding busbar, located in intermediate distribution frame rooms.
- E. TBB: Telecommunications bonding backbone, for connecting SBBs to PBB.
- F. TBC: Telecommunications bonding conductor, for connecting PBB to intersystem bonding termination device or busbar at electrical service entrance.
- G. TEBC: Telecommunications equipment bonding conductor, for connecting RBBs to SBBs or PBB.
- H. THHN: Thermoplastic High Heat-resistant Nylon-coated wire
- I. UBC: Unit bonding conductor, for connecting individual communications equipment to RBBs or SBBs.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field Quality-Control Submittals:
1. Field quality-control reports.

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.
- C. Comply with TIA-607-C
- D. Manufacturers: Match manufacturers specified in section 260526, where not possible, 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. Siemons.
 - 2. Panduit Corp.
 - 3. Krone.

2.2 CONDUCTORS

- A. Comply with UL 486A-486B
- B. Install solid conductor for No. 10 AWG and smaller.
- C. Install stranded conductor for No. 8 AWG and larger unless otherwise indicated.
- D. Insulated Conductors: Copper wire, green insulation, insulated for 600v, 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. Cable Tray Equipment Grounding Wire: No. 6 AWG.

2.3 CONNECTORS

- A. Irreversible connectors listed to 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.
- B. Busbar Connectors: Cast silicon Bronze, solderless compression-type, mechanical connector: with connector; with a long barrel and two holes spaced on 5/8" or 1" centers for a two-bolt connection to the busbar.

2.4 JUMPERS

- A. Cable Tray Grounding Jumper:
 - 1. Not smaller than No. 6 AWG and not longer than 12 inches.

2. If jumper is a wire, it shall have a crimped grounding lug with two (2) holes and long barrel for two (2) crimps.
3. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector by cable tray manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine facility's 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 electrical system.
- B. Inspect test results of grounding system measured at point of TBC connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of TBC only after unsatisfactory conditions have been corrected.

3.2 SELECTION OF COMMUNICATIONS BUSBARS

- A. Refer to Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 SELECTION OF COMMUNICATIONS BONDING CONDUCTORS

- A. Unless otherwise indicated in this Section or on Drawings, provide products specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Communications Busbar Connections:
 1. TBC: Not smaller than 3/0 AWG and no smaller than largest TBB.
 2. TBB: Not smaller than 2 kcmil per linear ft of conductor length, but not larger than 750 kcmil, unless otherwise indicated on Drawings.
 3. BBC: Not smaller than largest TBB to which it is connected unless otherwise indicated on Drawings.
 4. TEBC: Not smaller than 2 AWG unless otherwise indicated on Drawings. Provide bolted connectors.
 5. UBC: Not smaller than 6 AWG unless otherwise indicated on Drawings. Provide bolted connectors.
 6. Bonding Conductors to Structural Steel: Not smaller than 6 AWG unless otherwise indicated on Drawings. Provide bolted clamp connectors.

3.4 INSTALLATION OF BONDING FOR COMMUNICATIONS

- A. Comply with manufacturer's published instructions.

B. Reference Standards:

1. Bonding of Communications: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with TIA-568-C and TIA-607-C.
2. Consult Architect for resolution of conflicting requirements.

C. Special Techniques:

1. Busbars:
 - a. Grounding busbar locations shown on Drawings. Install busbars horizontally, on insulated spacers **12 inch** above finished floor unless otherwise indicated.
 - b. Where indicated on both sides of doorways, route conductor up to top of door frame, across top of doorway, and down; connect to horizontal bus.
2. Conductors:
 - a. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
 - b. Assemble wire connector to conductor, complying with manufacturer's published instructions and as follows:
 - 1) Use crimping tool and die specific to connector.
 - 2) Pretwist conductor.
 - 3) Apply antioxidant compound to bolted and compression connections.
 - c. Install in straightest and shortest route between origination and termination point, and no longer than required. Bend radius must not be smaller than 10 times diameter of conductor. No single bend may exceed 90 degrees.
 - d. Install without splices.
 - e. Support conductors at not more than **36 inch** intervals.
 - f. Outside telecommunications rooms, install conductors in the following manner:
 - 1) Below grade: Metric designator 21 (trade size 3/4) PVC-80 conduit.
 - 2) Above grade, exterior: Metric designator 21 (trade size 3/4) PVC-80 conduit.
 - 3) Above grade, interior: Metric designator 21 (trade size 3/4) EMT.
 - g. Where bonding conductor is installed in EMT or other ferrous metallic raceway, bond conductor to raceway using grounding bushing that complies with Section 270528 "Pathways for Communications Systems," and bond both ends of raceway to SBB.
3. Busbar Interconnections: Bond SBBs to PBB with TBBs. If more than one TBB is installed, bond TBBs together BBCs where required by TIA-607.
4. Structural Steel: Where structural steel of steel frame building is readily accessible within room or space, bond each SBB and PBB to vertical steel of building frame.
5. Communications Enclosures: Bond metallic enclosures of telecommunications equipment with UBCs to nearest SBB or PBB.
6. Equipment Racks: Bond metallic components of enclosures to RBB using UBCs. Provide top-mounted RBB if not provided by enclosure or rack manufacturer. Bond RBB to SBB with TEBC. Power connection must comply with NFPA 70; equipment grounding

conductor in power cord of cord- and plug-connected equipment must be considered supplemental to bonding requirements in this Section.

7. Shielded Cable: Bond shield of shielded cable to SBB in communications rooms and spaces. Comply with TIA-568.1 and TIA-568.2 when grounding shielded balanced twisted-pair cables.
8. Primary Protector: Bond to PBB with insulated bonding conductor.
9. Electrical Power Panelboards: Where electrical panelboards for communications equipment are located in same room or space, bond each ground bar of panelboard to SBB.
10. Cable Trays: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
11. Ladder Racks: Provide continuous electrical path by installing bonding clips and jumpers. Bond each end to nearest SBB.
12. Access Floors: Bond metal parts of access floors to SBB.

3.5 INSTALLATION OF GROUNDING AND BONDING FOR TOWERS AND ANTENNAS

A. Special Techniques:

1. Ring Electrode: Buried at least **30 inch** below grade and at least **24 inch** from base of tower or mounting.
2. Bond each tower base and metallic frame of dish to ring electrode, buried at least **18 inch** below grade.
3. Bond ring electrode and antenna bonding conductors to equipment room PBB or SBB, buried at least **30 inch** below grade.
4. Bond metal fences located within **6 ft** of towers and antennas to ring electrode, buried at least **18 inch** below grade.
5. Special Requirements for Roof-Mounted Towers:
 - a. Roof Ring: Meet requirements for ring electrode except conductors must comply with NFPA 780.
 - b. Bond tower base footings steel, SBB in equipment room, and antenna support guys to roof ring.
 - c. Connect roof ring to perimeter conductors of lightning protection system.
6. Special Requirements for Waveguides and Coaxial Cable:
 - a. Bond cable shields at point of entry into building to nearest SBB and to cable entrance plate, using 2 AWG bonding conductors.
 - b. Bond coaxial cable surge arrester to ring electrode or roof ring using bonding conductor size recommended by surge-arrester manufacturer.

3.6 IDENTIFICATION

- A. Comply with Section 270553 "Identification for Communications Systems."

3.7 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by authorities having jurisdiction.
- B. Tests and Inspections:
 - 1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with calibrated torque wrench according to manufacturer's published instructions.
 - 2. Test bonding connections of system using AC earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing PBB or SBB, using process recommended by BICSI N1. Conduct tests with facility in operation.
 - a. Measure resistance between PBB and electrical service intersystem termination point. Maximum acceptable value is 100 m Ω .
 - 1) If measured resistance from electrical service equipment to ground exceeds 5 Ω notify Architect and include recommendations to reduce resistance to ground.
 - b. Measure resistance between SBBs and PBB. Maximum acceptable value is 100 m Ω .
 - 3. Test for ground loop currents using digital clamp-on ammeter, with full scale not more than 10 A, displaying current in increments of 0.01 A at accuracy of plus or minus 2.0 percent.
 - a. With grounding infrastructure completed and communications system electronics operating, measure current in bonding conductors connected to PBB and, where applicable, to SBBs. Maximum acceptable AC current level is 1 A.
- C. Nonconforming Work:
 - 1. Communications bonding will be considered defective if it does not pass tests and inspections.
 - 2. Remove and replace defective units and retest.
- D. Collect, assemble, and submit test and inspection reports.

3.8 PROTECTION

- A. After installation, protect busbars and conductors from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

END OF SECTION 270526

SECTION 270528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Metal conduits and fittings.
2. Nonmetallic conduits and fittings.
3. Optical-fiber-cable pathways and fittings.
4. Metal wireways and auxiliary gutters.
5. Nonmetallic wireways and auxiliary gutters.
6. Metallic surface pathways.
7. Nonmetallic surface pathways.
8. Tele-power poles.
9. Hooks.
10. Boxes, enclosures, and cabinets.
11. Polymer-concrete handholes and boxes for exterior underground cabling.
12. Fiberglass handholes and boxes for exterior underground cabling.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.
- D. RTRC: Reinforced thermosetting resin conduit.

1.4 SUBMITTALS

- A. Product data for the following:

1. Surface pathways
2. Wireways and fittings.
3. Tele-power poles.
4. Boxes, enclosures, and cabinets.
5. Underground handholes and boxes.

- B. Sustainable Design Submittals:
 - 1. Product Data for solvents and adhesives, indicating VOC content.
 - 2. Laboratory Test Reports for solvents and adhesives, indicating compliance with requirements for low emitting materials.
- C. Shop Drawings: For custom enclosures and cabinets and custom underground handholes and boxes. Include plans, elevations, sections, and attachment details.
 - 1. For discontinuous supports (Hooks), indicate proposed pathways with sizing annotated, assembly, and mounting details.
- D. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC, plumbing items, lighting items, and architectural features in paths of conduit groups with common supports.
 - 3. Underground ducts, piping, and structures in location of underground enclosures and handholes.
- E. Qualification Data: For professional engineer.
- F. Seismic Qualification Data: Seismic rating for all pathway racks, enclosures, cabinets, equipment racks, and their mounting provisions, including those for internal components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
 - 4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.
- G. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Description: Metal raceway of circular cross section with manufacturer-fabricated fittings.
- B. Match manufacturers specified in section 260533.
- C. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.

- 2. Comply with TIA-569-D.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Set screw.
- F. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.2 SURFACE NONMETALLIC PATHWAYS:

- A. Description: Two- or three-piece construction, complying with UL 5A, and manufactured of rigid PVC.
- B. Match manufacturers specified in section 260533
- C. Finish: Texture and color selected by Architect from [**manufacturer's standard**] [**custom**] colors.
- D. Product shall comply with UL 94 V-0 requirements for self-extinguishing characteristics.
- E. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- F. Comply with TIA-569-E.

2.3 HOOKS

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Manufacturers: Match manufacturers specified in section 260533, where not possible, 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. B-Line
 - 2. Caddy
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-E.
- E. Galvanized steel.

- F. J shape.

2.4 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. Manufacturers: Match manufacturers specified in section 260533, where not possible, 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. Siemons.
 - 2. Ortronics.
 - 3. Panduit.
 - 4. Krone.
- C. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-E.
 - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.
 - 3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 - 4. Device Box Dimensions: **4 inches square by 2-1/8 inches deep.**
 - 5. Gangable boxes are prohibited.
- D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- F. Metal Floor Boxes specified and furnished in Section 260533.
- G. Nonmetallic Floor Boxes specified and furnished in Section 260533.
- H. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- I. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- J. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- K. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 4, with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures:
 - a. Material: Plastic.
 - b. Finished inside with radio-frequency-resistant paint.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

L. 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.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Concealed Conduit, Aboveground: EMT.
2. Boxes and Enclosures, Aboveground: NEMA 250, Type 4.

B. Indoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: EMT.
5. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: EMT.
6. Pathways for Concealed General-Purpose Distribution of Communications Cable: Plenum-type, communications-cable pathway.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.

C. Minimum Pathway Size: **3/4-inch** trade size for copper cables, and **1 inch** for optical-fiber cables.

D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

E. Install surface pathways only where indicated on Drawings.

F. Do not install nonmetallic conduit where ambient temperature exceeds [**120 deg F**].

3.2 INSTALLATION

A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. TIA-569-E.

3. NECA 101
 4. NECA 102.
 5. NECA 105.
 6. NECA 111.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- D. Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems" for hangers and supports.
- E. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" for sleeves and sleeve seals for communications.
- F. Keep pathways at least **6 inches** away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- G. Complete pathway installation before starting conductor installation.
- H. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- I. Install no more than the equivalent of two 90-degree bends in any pathway run. Support within **12 inches** of changes in direction. Utilize long radius ells for all optical-fiber cables.
- J. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- K. Support conduit within **12 inches** of enclosures to which attached.
- L. Pathways Embedded in Slabs:
1. Run conduit larger than trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum **10-foot** intervals.
 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
 3. Arrange pathways to keep a minimum of **2 inches** of concrete cover in all directions.
 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- M. Stub-ups to Above Recessed Ceilings:
1. Use EMT for pathways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- N. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound

manufacturer's written instructions.

- O. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- P. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- Q. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- R. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure, to assure a continuous ground path.
- S. Cut conduit perpendicular to the length. For conduits of **2-inch** trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- T. Install pull wires in empty pathways. 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. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- U. Surface Pathways:
 - 1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
 - 2. Install surface pathway with a minimum **2-inch** radius control at bend points.
 - 3. Secure surface pathway with screws or other anchor-type devices at intervals not exceeding **48 inches** and with no less than two supports per straight pathway section. Support surface pathway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- V. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 - 1. **3/4-Inch** Trade Size and Smaller: Install pathways in maximum lengths of **50 feet**.
 - 2. **1-Inch** Trade Size and Larger: Install pathways in maximum lengths of **75 feet**.
 - 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway 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.
- W. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, 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 pathway-sealing fittings according to NFPA 70.
- X. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where an underground service pathway enters a building or structure.
 3. Where otherwise required by NFPA 70.
- Y. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- Z. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed **30 deg F**, and that has straight-run length that exceeds **25 feet**. Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed **100 deg F**, and that has straight-run length that exceeds **100 feet**.
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: **125 deg F** temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: **155 deg F** temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: **125 deg F** temperature change.
 - d. Attics: **135 deg F** temperature change.
 3. Install fitting(s) that provide expansion and contraction for at least **0.00041 inch per foot of length of straight run per deg F** of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least **0.000078 inch per foot of length of straight run per deg F** of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- AA. Hooks:
1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 3. Hook spacing shall allow no more than **6 inches** of slack. The lowest point of the cables shall be no less than **6 inches** adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 4. Space hooks no more than **5 feet** o.c.
 5. Provide a hook at each change in direction.
- BB. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to top of box unless otherwise indicated.
- CC. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block,

and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

- DD. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS 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. Steel slotted support systems for communication raceways.
2. Aluminum slotted support systems for communication raceways.
3. Nonmetallic slotted support systems for communication raceways.
4. Conduit and cable support devices.
5. Support for conductors in vertical conduit.
6. Structural steel for fabricated supports and restraints.
7. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
8. Fabricated metal equipment support assemblies.

1.3 SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Slotted support systems, hardware, and accessories.
 - b. Clamps.
 - c. Hangers.
2. Include rated capacities and furnished specialties and accessories.

- B. Shop Drawings: Signed and sealed by a qualified professional engineer. For fabrication and installation details for communications hangers and support systems.

1. Trapeze hangers. Include product data for components.
2. Steel slotted-channel systems.
3. Aluminum slotted-channel systems.
4. Nonmetallic slotted-channel systems.
5. Equipment supports.

6. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: For hangers and supports for communications systems.
1. Include design calculations and details of trapeze hangers.
- D. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
 2. Ductwork, piping, fittings, and supports.
 3. Structural members to which hangers and supports will be attached.
 4. Size and location of initial access modules for acoustical tile.
 5. Items penetrating finished ceiling, including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Projectors.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified structural professional engineer to design hanger and support system.
- 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 Rating: Class 1.
 2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
 1. Manufacturers: Match manufacturers specified in section 260529, where not possible, 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. Hubbell Premise Wiring; brand of Hubbell Data-Comm; Hubbell Incorporated.
 - b. Panduit Corp.
 - c. CPI Chatsworth Products..

2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Material for Channel, Fittings, and Accessories: Galvanized steel.
 4. Channel Width: **1-5/8 inches**, except where contractor determines another size meets the applicable load criteria.
 5. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 9. Channel Dimensions: Selected for applicable load criteria.
- B. Aluminum Slotted Support Systems: Extruded aluminum channels and angles with minimum **13/32-inch**- diameter holes at a maximum of **8 inches** o.c. in at least one surface.
1. Manufacturers: Match manufacturers specified in section 260529, where not possible, 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. Hubbell Premise Wiring; brand of Hubbell Data-Comm; Hubbell Incorporated.
 - b. Panduit Corp.
 - c. CPI Chatsworth Products.
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Channel Material: 6063-T6 aluminum alloy.
 4. Fittings and Accessories Material: 5052-H32 aluminum alloy.
 5. Channel Width: **1-5/8 inches**, except where contractor determines another size meets the applicable load criteria.
 6. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 7. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 8. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 9. Channel Dimensions: Selected for applicable load criteria.
- C. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with minimum **13/32-inch**- diameter holes at a maximum of **8 inches** o.c., in at least one surface.
1. Manufacturers: Match manufacturers specified in section 260529, where not possible, 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. Hubbell Premise Wiring; brand of Hubbell Data-Comm; Hubbell Incorporated.
 - b. Panduit Corp.
 - c. CPI Chatsworth Products.
 2. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 3. Channel Width: **1-5/8 inches**, except where contractor determines another size meets the applicable load criteria.
 4. Fittings and Accessories: Products provided by channel and angle manufacturer and designed for use with those items.
 5. Fitting and Accessory Materials: Same as those for channels and angles.
 6. Rated Strength: Selected to suit applicable load criteria.

7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- D. Conduit and Cable Support Devices: Steel clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E. 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.
- F. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M steel plates, shapes, and bars; black and galvanized.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. 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:
 1. NECA 1.
 2. TIA-569-E.
 3. NECA 101.
 4. NECA 102.
 5. NECA 105.
 6. NECA 111.
- B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- C. Comply with requirements for pathways specified in Section 270528 "Pathways for Communications Systems."
- D. 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.

- E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 INSTALLATION OF SUPPORTS

- A. 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.
- 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.
- C. 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:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Use 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 thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.

- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor communications materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M. Submit welding certificates.

3.4 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**.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780.

END OF SECTION 270529

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS 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. Ladder cable tray.
2. Wire-mesh cable tray.
3. Cable tray accessories.
4. Warning signs.

1.3 SUBMITTALS

- A. Product Data: For each type of cable tray.

1. Include data indicating dimensions and finishes for each type of cable tray indicated.

- B. Shop Drawings: For each type of cable tray.

1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
2. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
 - a. Vertical and horizontal offsets and transitions.
 - b. Clearances for access above and to sides of cable trays.
 - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
 - d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

- C. Delegated-Design Submittal: For seismic restraints.

1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
2. Design Calculations: Calculate requirements for selecting seismic restraints.
3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

- D. Coordination Drawings: Floor plans and sections, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements.
 - 2. Vertical and horizontal offsets and transitions.
 - 3. Clearances for access above and to side of cable trays.
 - 4. Vertical elevation of cable trays above the floor or below bottom of ceiling structure.
- E. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 - 1. Source Limitations: Obtain cable trays and components from single manufacturer.
- B. Sizes and Configurations: See Drawings for specific requirements for types, materials, sizes, and configurations.
- C. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:
 - 1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 - 2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 - 3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAY

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. B-Line (Lees Summit Standard)
 - 2. Hubbell Premise Wiring; brand of Hubbell Data-Comm; Hubbell Incorporated.
 - 3. Panduit Corp.

4. CPI Chatsworth Products.

B. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
2. Width: **12 inches** unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: **4 inches**.
4. Straight Section Lengths: **10 feet**, except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: **6 inches** o.c.
6. Minimum Cable-Bearing Surface for Rungs: **7/8-inch** width with radius edges.
7. No portion of the rungs shall protrude below the bottom plane of side rails.
8. Structural Performance of Each Rung: Capable of supporting a maximum cable load, with a safety factor of 1.5, plus a **200-lb** concentrated load, when tested according to NEMA VE 1.
9. Splicing Assemblies: Bolted type using serrated flange locknuts.
10. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
 - a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A1008/A1008M, Grade 33, Type 2.
 - b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - d. Finish:
 - 1) Pre-galvanized after fabrication, complying with ASTM A123/A123M, Class B2, with Galvanized, ASTM B633 hardware.

2.4 WIRE-MESH CABLE TRAY

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

1. B-Line. (Lees Summit Standard)
2. GS Metals. (Lees Summit Standard)
3. Wiremold. (Lees Summit Standard)

B. Description:

1. Configuration: Galvanized steel wire mesh, complying with NEMA VE 1.
2. Width: **12 inches** unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: **4 inches**.

4. Straight Section Lengths: **10 feet**, except where shorter lengths are required to facilitate tray assembly.
5. 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.
6. Splicing Assemblies: Bolted type using serrated flange locknuts.
7. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Steel:
 - a. Straight Sections and Fittings: Steel complies with the minimum mechanical properties of ASTM A1008/A1008M, Grade 33, Type 2.
 - b. Steel Tray Splice Plates: ASTM A1011/A1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A510/A510M, Grade 1008.
 - d. Finish:
 - 1) Pre-galvanized, complying with ASTM A123/A123M, Class B2, with Galvanized, ASTM B633 hardware.

2.5 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.6 WARNING SIGNS

- A. Comply with requirements for identification in Section 270553 "Identification for Communications Systems."
- B. 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."

2.7 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA VE 2.

- B. 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.
- C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Fasten cable tray supports to building structure and install seismic restraints, if applicable.
- F. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of **200 lb** . Comply with requirements in Section 270529 "Hangers and Supports for Communications Systems."
- G. 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.
- H. 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.
- I. Support assembly to prevent twisting from eccentric loading.
- J. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
- K. Do not install more than one cable tray splice between supports.
- L. Make connections to equipment with flanged fittings fastened to cable trays and to equipment. Support cable trays independent of fittings. Do not carry weight of cable trays on equipment enclosure.
- M. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed recommended dimensions. Space connectors and set gaps according to applicable standard.
- N. Make changes in direction and elevation using manufacturer's recommended fittings.
- O. Make cable tray connections using manufacturer's recommended fittings.
- P. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 078413 "Penetration Firestopping."
- Q. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- R. Install cable trays with enough workspace to permit access for installing cables.
- S. Install permanent covers and cover clamps, if used, after installing cable.

- T. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- U. Install warning signs in visible locations on or near cable trays after cable tray installation.

3.2 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems."
- B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. 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.
- D. Bond cable trays to power source for cables contained within with bonding conductors sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors."

3.3 CABLE INSTALLATION

- 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** elsewhere.
- F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2.

3.5 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements.
2. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable trays, vibrations, and thermal expansion and contraction conditions, which may cause or have caused damage.
3. Verify that the number, size, and voltage of cables in cable trays do not exceed that permitted by NFPA 70. Verify that communications or data-processing circuits are separated from power circuits by barriers or are installed in separate cable trays.
4. Verify that there are no intruding items such as pipes, hangers, or other equipment in the cable tray.
5. Remove dust deposits, industrial process materials, trash of any description, and any blockage of tray ventilation.
6. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorqued in suspect areas.
7. Check for improperly sized or installed bonding jumpers.
8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND CABLING

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. Round sleeves.
 - 2. Rectangular sleeves.
 - 3. Sleeve seal systems.
 - 4. Grout.
 - 5. Pourable sealants.
 - 6. Foam sealants.

1.3 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ROUND SLEEVES

- A. Wall Sleeves, Steel:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. STI Firestop
 - b. Hilti
 - c. 3M
 - 2. Description: ASTM A53/A53M, Type E, Grade B, Schedule 40, zinc coated, plain ends and integral waterstop.

2.2 SLEEVE SEAL SYSTEMS

- 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. STI Firestop
 - b. Hilti
 - c. 3M
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable or between pathway and cable.
 - 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.

PART 3 - EXECUTION

3.1 INSTALLATION OF SLEEVES FOR NON-FIRE-RATED COMMUNICATIONS PENETRATIONS

- A. Comply with NECA 1.
- B. Sleeves for Conduits Penetrating Above-Grade, Non-Fire-Rated, Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall or floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - b. Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Section 079200 "Joint Sealants."
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide **1/4-inch** annular clear space between sleeve and pathway or cable, unless sleeve seal system is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors **3 inches** above finished floor level. Install sleeves during erection of floors.
- C. Sleeves for Conduits Penetrating Non-Fire-Rated Wall Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for wall assemblies.
- D. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

- E. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seal systems. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- F. Underground, Exterior-Wall and Floor Penetrations:
 - 1. Install steel pipe sleeves with integral waterstops. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve seal system. Install sleeve during construction of floor or wall.
 - 2. Install steel pipe sleeves. Size sleeves to allow for 1-inch annular clear space between pathway or cable and sleeve for installing sleeve seal system. Grout sleeve into wall or floor opening.

3.2 INSTALLATION OF SLEEVE SEAL SYSTEMS

- A. Install sleeve seal systems in sleeves in exterior concrete walls and slabs-on-grade at pathway entries into building.
- B. 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.

END OF SECTION 270544

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS 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. Underground-line warning tape.
 - 2. Signs.
 - 3. Bands and tubes.
 - 4. Cable ties.
 - 5. Miscellaneous identification products.
 - 6. Labels.

1.3 SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.
- B. 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, ambient; 180 deg F, 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- thick, vinyl 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:
 - a. Permanent, waterproof black ink marker recommended by tag manufacturer.
 - b. Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches 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 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".

C. Tag, Detectable:

1. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
2. Width: **3 inches**.
3. Overall Thickness: **5 mils**.
4. Foil Core Thickness: **0.35 mil**.
5. Weight: **28 lb/1000 sq. ft.**
6. Tensile according to ASTM D882: **70 lbf** and **4600 psi**.

2.6 SIGNS

A. Baked-Enamel Signs:

1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
2. **1/4-inch** grommets in corners for mounting.
3. Nominal Size: **7 by 10 inches**.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with **0.0396-inch** galvanized-steel backing, punched and drilled for fasteners, and with colors, legend, and size required for application.
2. **1/4-inch** grommets in corners for mounting.
3. Nominal Size: **10 by 14 inches**.

C. Laminated-Acrylic or Melamine-Plastic Signs:

1. Engraved legend.
2. Thickness:
 - a. For signs up to **20 sq. in.**, minimum **1/16 inch** thick.
 - b. For signs larger than **20 sq. in.**, **1/8 inch** thick.
 - c. Engraved legend with black letters on white face.

- d. Punched or drilled for mechanical fasteners with 1/4-inch grommets in corners for mounting.
- e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.7 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.
 - 2. Tensile Strength at 73 deg F according to ASTM D638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 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.
 - 2. Tensile Strength at 73 deg F according to ASTM D638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black.
- C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying 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** 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** 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** 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-** high letters on **1-1/2-inch-** high label; where two lines of text are required, use labels **2 inches** 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** below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds **16 inches** overall.
2. 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. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
 1. System legends shall be as follows:
 - a. Telecommunications.
- D. 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. Dash.
 3. Cable landing rack destination.
 4. Dash
 5. Patch Panel Label
 6. Patch Panel Port
- E. 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 and outlets, starting at top 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.

- F. Backbone Cables: Label each cable with a self-adhesive 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.
- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:
 - 1. Wiring closet designation.
 - 2. Dash.
 - 3. Cable landing rack destination.
 - 4. Dash
 - 5. Patch Panel Label
 - 6. Patch Panel Port
- H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
- I. Instructional Signs: Self-adhesive labels.
- J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.
 - 1. Apply to exterior of door, cover, or other access.
- K. Equipment Identification Labels:
 - 1. Indoor Equipment: Self-adhesive label.
 - 2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign.
 - 3. Equipment to Be Labeled:
 - a. Communications cabinets.
 - b. Uninterruptible power supplies.
 - c. Computer room air conditioners.
 - d. Fire-alarm and suppression equipment.
 - e. Egress points.
 - f. Power distribution components.

END OF SECTION 270553

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

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. Backboards.
 - 2. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. BICSI: Building Industry Consulting Service International.
- C. RCDD: Registered communications distribution designer.
- D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.
- E. TGB: Telecommunications grounding bus bar.
- F. TMGB: Telecommunications main grounding bus bar.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- B. Seismic Qualification Data: Certificates, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.
 1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of Technician.
 2. Installation Supervision: Installation shall be under direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
 3. Field Inspector: Currently registered by BICSI as Technician to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, **3/4 by 48 by 96 inches.**
- B. Backboard Paint: Light-colored fire-retardant paint.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Krone
 - 2. Panduit Corp.
 - 3. Ortronics
 - 4. Siemens
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed and labeled for intended location and use.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, Type FD, aluminum, with gasketed cover.
- E. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Device Box Dimensions: **4 inches square by 2-1/8 inches deep.**
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, type as appropriate to location with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic.
 - 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
 - 1. NEMA 250, type as appropriate to location 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.

6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
- B. Comply with requirements in Section 270528 "Pathways for Communications Systems".

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.
- C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in 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 tracks and in room. Coordinate service entrance configuration with service provider.
 1. Meet jointly with systems 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 rooms to accommodate and optimize configurations and space requirements of communications 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. Backboards:
 1. Install from 6 inches to 8 feet, 6 inches above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
 2. Paint all sides of backboard with two coats of paint, leaving fire rating stamp visible.
 3. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.

3.3 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI's "Information Technology Systems Installation Methods Manual," "Firestopping Practices" Ch.

END OF SECTION 271100

SECTION 271116 - COMMUNICATIONS RACKS, FRAMES, AND ENCLOSURES

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. 19-inch equipment racks.
2. Power strips.
3. Grounding.
4. Labeling.

B. Related Requirements:

1. Section 271110 "Communications Equipment Room Fittings" for backboards and accessories.
2. Section 270526 "Grounding and Bonding for Telecommunications Equipment" for TMGBs and TGBs.
3. Section 270536 "Cable Trays for Communications Systems" for cable trays and cable tray accessories.
4. Section 271300 "Communications Backbone Cabling" for copper data cabling associated with system panels and devices.
5. Section 271500 "Communications Horizontal Cabling" for copper data cabling associated with system panels and devices.

1.3 DEFINITIONS

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. BICSI: Building Industry Consulting Service International.
- C. LAN: Local area network.
- D. RCDD: Registered communications distribution designer.
- E. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.
- F. TGB: Telecommunications grounding bus bar.

- G. TMGB: Telecommunications main grounding bus bar.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 2. Include rated capacities, operating characteristics, electrical characteristics, certifications, standards compliance, and furnished specialties and accessories.
- B. Shop Drawings: For communications racks, frames, and enclosures. Include plans, elevations, sections, details, and attachments to other work.
 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 3. Grounding: Indicate location of PBB/SBB and its mounting detail showing standoff insulators and wall-mounting brackets.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- B. Seismic Qualification Data: Certificates, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling installer must have personnel certified by BICSI on staff.
 1. Layout Responsibility: Preparation of Shop Drawings shall be under direct supervision of RCDD.
 2. Installation Supervision: Installation shall be under direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
 3. Field Inspector: Currently registered by BICSI as RCDD to perform on-site inspection.

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**. Comply with requirements for plywood backing panels specified in Section 061000 "Rough Carpentry."

2.3 19-INCH EQUIPMENT RACKS

- A. Description: Two- post racks with threaded rails designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, **19-inch** equipment mounting with an opening of **17.72-inches** between rails.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. B-Line (Part Number SB-556-084-XU) (Lees Summit Standard)
 - 2. Panduit.
 - 3. Hubbell.
- C. General Requirements:
 - 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Material: Extruded steel.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 - 4. Color: Black.
- D. Floor-Mounted Racks:
 - 1. Overall Height: **84 inches**.
 - 2. Overall Depth: 16 inches.
 - 3. Upright Depth: **3 inches**.
 - 4. Two-Post Load Rating: 1000 lbs.
 - 5. Number of Rack Units per Rack: 45.
 - a. Numbering: **[Every] [Every five]** rack units, on interior of rack.
 - 6. Threads: **[10-32] [12-24] [Universal square]**.
 - 7. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug[, **and a power strip**].
 - 8. Base shall have a minimum of four mounting holes for permanent attachment to floor.

9. Top shall have provisions for attaching to cable tray or ceiling.
10. Self-leveling.

E. Wall-Mounted Racks:

1. Height: [18 inches] [22 inches] [As indicated on Drawings] <Insert value>.
2. Depth: [23 inches] [29 inches] <Insert value>.
3. Load Rating: [150 lb] [200 lb] <Insert value>.
4. Number of Rack Units per Rack: [8] [12] [22] [As indicated on Drawings] <Insert number>.
5. Threads: [10-32] [12-24] [Universal square].
6. Wall Attachment: Four mounting holes.
7. Equipment Access: Integral swing.

F. 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.

2.4 19-INCH EQUIPMENT CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with EIA/ECIA 310-E, 19-inch equipment mounting with an opening of 17.72 inches between rails.

- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.

1. Hubbell.
2. Panduit Corp.

C. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: [Extruded steel] [Extruded aluminum] [Sheet steel] [Sheet aluminum].
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: [Black] <Insert color>.

D. Modular Freestanding Cabinets:

1. Overall Height: [72 inches] [84 inches] [As indicated on Drawings] <Insert value>.
2. Overall Depth: [23 inches] [29 inches] <Insert value>.
3. Load Rating: [3000 lb] <Insert value>.
4. Number of Rack Units: [38] [42] [45] [52] [58] [As indicated on Drawings] <Insert number>.

- a. Numbering: **[Every] [Every five]** rack units, on interior of rack.
 - 5. Threads: **[10-32] [12-24] [Universal square]**.
 - 6. Removable and lockable side and top panels.
 - 7. Hinged and lockable front and rear doors.
 - 8. Adjustable feet for leveling.
 - 9. Screened ventilation openings in roof and rear door.
 - 10. Cable access provisions in roof and base.
 - 11. TGB.
 - 12. **[Rack] [Roof]**-mounted, **550-cfm** fan with filter.
 - 13. Power strip.
 - 14. All cabinets keyed alike.
- E. Modular Wall Cabinets:
- 1. Height: **[18 inches] [22 inches] [As indicated on Drawings]** <Insert value>.
 - 2. Depth: **[23 inches] [29 inches]** <Insert value>.
 - 3. Load Rating: **[150 lb] [200 lb]** <Insert value>.
 - 4. Number of Rack Units: **[8] [12] [22] [As indicated on Drawings]** <Insert number>.
 - 5. Threads: **[10-32] [12-24] [Universal square]**.
 - 6. Lockable front[**and rear**] doors.
 - 7. Louvered side panels.
 - 8. Cable access provisions top and bottom.
 - 9. Grounding lug.
 - 10. **[Rack] [Roof]**-mounted, **250-cfm** fan.
 - 11. Power strip.
 - 12. All cabinets keyed alike.
- F. 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 top of each relay rack, with a minimum height of two rack units each.

2.5 23-INCH EQUIPMENT CABINETS

- A. Description: Manufacturer-assembled four-post frame enclosed by side and top panels and front and rear doors, designed for mounting telecommunications equipment. Width is compatible with **23-inch** equipment mounting.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Hubbell.
 - 2. Panduit Corp.
- C. General Cabinet Requirements:

1. Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Material: [Extruded steel] [Extruded aluminum] [Sheet steel] [Sheet aluminum].
3. Finish: Manufacturer's standard, baked-polyester powder coat.
4. Color: [Black] <Insert color>.

D. Modular Freestanding Cabinets:

1. Overall Height: [72 inches] [84 inches] [As indicated on Drawings] <Insert value>.
2. Overall Depth: [23 inches] [29 inches] <Insert value>.
3. Load Rating: [3000 lb] <Insert value>.
4. Number of Rack Units: [38] [42] [45] [52] [58] [As indicated on Drawings] <Insert number>.
 - a. Numbering: [Every] [Every five] rack units, on interior of rack.
5. Threads: [10-32] [12-24] [Universal square].
6. Removable and lockable side and top panels.
7. Hinged and lockable front and rear doors.
8. Adjustable feet for leveling.
9. Screened ventilation openings in roof and rear door.
10. Cable access provisions in roof and base.
11. TGB.
12. [Rack] [Roof]-mounted, 550-cfm fan with filter.
13. Power strip.
14. All cabinets keyed alike.

E. Modular Wall Cabinets:

1. Height: [18 inches] [22 inches] [As indicated on Drawings] <Insert value>.
2. Depth: [23 inches] [29 inches] <Insert value>.
3. Load Rating: [150 lb] [200 lb] <Insert value>.
4. Number of Rack Units: [8] [12] [22] [As indicated on Drawings] <Insert number>.
5. Threads: [10-32] [12-24] [Universal square].
6. Lockable front[and rear] doors.
7. Louvered side panels.
8. Cable access provisions top and bottom.
9. Grounding lug.
10. [Rack] [Roof]-mounted, 250-cfm fan.
11. Power strip.
12. All cabinets keyed alike.

F. 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 top of each relay rack, with a minimum height of two rack units each.

2.6 OPEN RACK EQUIPMENT RACKS

- A. Description: Four-post racks with integral bus bars, equipment support, and dimensions meeting Open Rack Standard v1.2.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Hubbell.
 - 2. Panduit Corp.
- C. General Requirements:
 - 1. Frames: Four vertical columns, with perforated top and bottom.
 - 2. Support Shelves: Designed to support equipment 1 OpenU (48 mm) in height.
 - 3. Material:
 - a. Frames and Shelves: **[Extruded steel] [Extruded aluminum] [Sheet steel] [Sheet aluminum].**
 - b. Bus Bars: Nickel plated copper[, **with silver over-plating**] [, **with gold over-plating**].
 - 4. Finish:
 - a. Frames: Manufacturer's standard, baked-polyester powder coat.
 - b. Shelves: Hot-dip galvanized according to ASTM A653/A653M.
 - 5. Color: **[Black] <Insert color>.**
 - 6. Height: 2100 mm.
 - 7. Width: 600 mm.
 - 8. Depth: 1607 mm.
 - 9. Base shall have a minimum of four **[mounting holes] [height-adjustable feet]** for permanent attachment to floor[, **and four casters to allow easy repositioning of rack**].
 - 10. Top shall have provisions for attaching to cable tray or ceiling.
 - 11. Self-leveling.

2.7 POWER STRIPS

- A. Power Strips: Comply with UL 1363.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Rack mounting.
 - 3. **[Six] <Insert number> [15-A, 120-V ac, NEMA WD 6, Configuration 5-15R] [20-A, 120-V ac, NEMA WD 6, Configuration 5-20R]** receptacles.
 - 4. LED indicator lights for power and protection status.
 - 5. LED indicator lights for reverse polarity and open outlet ground.
 - 6. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
 - 7. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
 - 8. **[Close-coupled, direct plug-in] [Cord connected with 15-foot]** line cord.

9. Rocker-type on-off switch, illuminated when in on position.
10. Peak Single-Impulse Surge Current Rating: [33] [26] [13] kA per phase.
11. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all three modes shall be not more than [330 V] <Insert value>.

2.8 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 1. Hubbell.
 2. Panduit Corp.
- C. Rack and Cabinet TGBs: 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-606-B. Predrilling shall be with holes for use with lugs specified in this Section.
 1. Cabinet-Mounted TGB: Terminal block, with stainless-steel or copper-plated hardware for attachment to cabinet.
 2. Rack-Mounted Horizontal TGB: Designed for mounting in 19- or 23-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 TGB: 72 or 36 inches long, with stainless-steel or copper-plated hardware for attachment to rack.

2.9 LABELING

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 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.

3.2 GROUNDING

- A. Comply with NECA/BICSI 607.
- B. Install grounding according to BICSI ITSIMM, "Bonding, Grounding (Earthing) and Electrical Protection" Ch.
- C. Locate TGB to minimize length of bonding conductors. Fasten to wall, allowing at least **2 inches** of clearance behind TGB. Connect TGB with a minimum No. 4 AWG grounding electrode conductor from TGB to suitable electrical building ground. Connect rack TGB to near TGB or the TMGB.
 1. Bond the shield of shielded cable to patch panel, and bond patch panel to TGB or TMGB.

3.3 IDENTIFICATION

- A. Coordinate system components, wiring, and cabling complying with TIA-606-B. Comply with requirements in Section 270553 "Identification for Electrical Systems."
- B. Comply with requirements in Section 099123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- C. Paint and label colors for equipment identification shall comply with TIA-606-B for **[Class 2] [Class 3] [Class 4]** level of administration[, **including optional identification requirements of this standard**].
- D. Labels shall be machine printed. Type shall be **[1/8 inch] [3/16 inch] [1/4 inch]** in height.

END OF SECTION 271116

SECTION 271500 - COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Category 6a twisted pair cable.
2. Twisted pair cable hardware, including plugs and jacks.
3. Multiuser telecommunications outlet assembly.
4. Cable management system.
5. Cabling identification products.
6. Grounding provisions for twisted pair cable.
7. Source quality control requirements for twisted pair cable.
8. 850 nanometer laser-optimized 50/125 micrometer multimode optical fiber cable (OM4).
9. Optical fiber cable connecting hardware, patch panels, and cross-connects.
10. Communications coaxial cable.
11. CATV coaxial cable.
12. Coaxial cable hardware.
13. Grounding.
14. Identification products.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for data cabling associated with system panels and devices.

1.2 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. FTP: Shielded twisted pair.
- D. F/FTP: Overall foil screened cable with foil screened twisted pair.
- E. F/UTP: Overall foil screened cable with unscreened twisted pair.
- F. IDC: Insulation displacement connector.
- G. LAN: Local area network.
- H. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- I. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.

- J. RCDD: Registered Communications Distribution Designer.
- K. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- L. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- M. S/FTP: Overall braid screened cable with foil screened twisted pair.
- N. S/UTP: Overall braid screened cable with unscreened twisted pairs.
- O. UTP: Unscreened (unshielded) twisted pair.

1.3 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., and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.4 SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. System Labeling Schedules:
 - a. Electronic copy of labeling schedules, in software and format selected by Owner.
 - b. Electronic copy of labeling schedules that are part of cabling and asset identification system of software.
 - 2. Cabling administration Drawings and printouts.
 - 3. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.

- b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.
- C. Cable testing plan.
- D. Samples: For telecommunications jacks and plugs, in specified finish, one for each type and configuration and cover plates for color selection and evaluation of technical features.
- E. Field Quality-Control Submittals:
 - 1. Field quality-control reports.
 - 2. Samples: For telecommunications jacks and plugs, **in specified finish, one for each type and configuration.**
- F. Qualification Data: For installation supervisor, and field inspector.
- G. Product Certificates: For each type of product.
- H. Source quality-control reports.
- I. Maintenance Data: For splices and connectors to include in maintenance manuals.
- J. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On USB media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
- K. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Connecting Blocks: One of each type.
 - 2. Cover Plates: One of each type.
 - 3. Jacks: Ten of each type.
 - 4. Multiuser Telecommunications Outlet Assemblies: One of each type.
 - 5. Patch-Panel Units: One of each type.
 - 6. Plugs: Ten of each type.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.

- B. Testing Agency Qualifications: Testing agency must have personnel certified by BICSI on staff.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.8 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.9 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
 - 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

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:
 - a. Type CMP complying with UL 1685 or Type CMP in listed plenum communications raceway.
 - b. 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."
 - 2. Communications, Non-Plenum Rated:
 - a. Type CMR complying with UL 1666.
 - b. Type CMP or Type CMR in listed plenum or riser communications raceway.
 - c. 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] <Insert value> or less.
 - 2. Smoke-Developed Index: [50] [450] <Insert value> or less.
- C. RoHS compliant.

2.3 CATEGORY 6a TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6a cable at frequencies up to 500 MHz.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Mohawk.
 - 2. Berk-Tek.
 - 3. Belden.
 - 4. Commscope.
 - 5. Krone.
- C. Standard: Comply with TIA-568-C.2 for Category 6a cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP).
- F. Cable Rating: Plenum.
- G. Jacket: Blue thermoplastic.

2.4 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Ortronics
 - 2. Panduit Corp.
 - 3. Siemons.
 - 4. Krone.
- C. General Requirements for Twisted Pair Cable Hardware:
 - 1. Comply with the performance requirements of Category 6a.
 - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 - 3. Cables shall be terminated with connecting hardware of same category or higher.
- D. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.
- E. Connecting Blocks:
 - 1. 110-style IDC for Category 5e.
 - 2. 66-style IDC for Category 5e.
 - 3. 110-style IDC for Category 6.
 - 4. 110-style IDC for Category 6a.
 - 5. Provide blocks for the number of cables terminated on the block, plus [25] **<Insert number>** percent spare, integral with connector bodies, including plugs and jacks where indicated.
- F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
- G. 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.
 - 1. Features:
 - a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 - 2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
 - 3. Number of Jacks per Field: One for each four-pair cable indicated.

- H. Patch Cords: Factory-made, four-pair cables in 36-inch lengths; terminated with an eight-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.
- I. Plugs and Plug Assemblies:
 - 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Standard: Comply with TIA-568-C.2.
 - 3. Marked to indicate transmission performance.
- J. Jacks and Jack Assemblies:
 - 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Designed to snap-in to a patch panel or cover plate.
 - 3. Standard: Comply with TIA-568-C.2.
 - 4. Marked to indicate transmission performance.
- K. Cover Plate:
 - 1. Four port, vertical single gang cover plates designed to mount to single gang wall boxes.
 - 2. Twelve port, vertical double gang cover plates designed to mount to double gang wall boxes.
 - 3. Plastic Cover Plate: High-impact plastic. Coordinate color with Section 260533 "Raceway and Boxes for Electrical Systems."
 - 4. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
- L. Legend:
 - 1. Snap-in, clear-label covers and machine-printed paper inserts.

2.5 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

- A. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Ortronics
 - 2. Panduit Corp.
 - 3. Siemons.
 - 4. Krone.
- B. Description: MUTOAs shall meet the requirements of "Twisted Pair Cable Hardware" Article.
 - 1. Number of Terminals per Field: One for each conductor in assigned cables.
 - 2. Number of Connectors per Field:

- a. One for each four-pair unshielded or shielded twisted-pair cable indicated.
- 3. Mounting: Furniture.
- 4. NRTL listed as complying with UL 50 and UL 1863.
- 5. Label shall include maximum length of work area cords, based on TIA-568-C.1.
- 6. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.6 IDENTIFICATION PRODUCTS

- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.7 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test cables on reels according to TIA-568-C.1.
- C. Factory test twisted pair cables according to TIA-568-C.2.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

2.8 OPTICAL FIBER CABLE HARDWARE

- A. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 - 1. Ortronix.
 - 2. SignaMax
 - 3. Black Box.
 - 4. Corning.
 - 5. Leviton.

2.9 GENERAL COAXIAL CABLE CHARACTERISTICS

- A. Communications Cable: 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 per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. CATV Cable: 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. CATV Plenum Rated: Type CATVP installed in riser raceways or cable routing assemblies, complying with NFPA 262.
2. CATV Cable: Type CATV, or CATVP or CATVR installed in general purpose, riser, or plenum communications raceways or cable routing assemblies in fireproof riser shafts with firestops at each penetration.

2.10 CATV COAXIAL CABLE

- A. Description: Coaxial cable with a 75-ohm characteristic impedance designed for CATV transmission.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 1. [Ortronics](#)
 2. [Panduit Corp.](#)
 3. Siemons.
 4. Krone.
- C. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Community Antenna Television and Radio Distribution Systems" Article. Types are as follows:
 1. RG-6/U: UL Type CATVP.
 - a. No. 18 AWG, solid, copper-covered steel conductor.
 - b. Plenum rated.
 - c. Gas-injected, foam-PE insulation.
 - d. Shielded with 100 percent aluminum tape and 40 percent aluminum braid.
 - e. Jacketed with black PVC or PE.
 - f. Suitable for indoor installations.

2.11 COAXIAL CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate coaxial cable with a 75-ohm characteristic impedance.
- B. Manufacturers: Must meet all project requirements. Basis of Design manufacturers are listed below, substitutions allowed if approved through Submittal process.
 1. [Ortronics](#)
 2. [Panduit Corp.](#)
 3. Siemons.
 4. Krone.
- C. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- D. Jacks and Jack Assemblies: Modular, color-coded, with female Type BNC connectors.
- E. Patch Cords: Factory-made cables in 48-inch lengths; terminated with a male Type BNC connector at each end.

F. Faceplates:

1. Plastic Faceplate: High-impact plastic. Coordinate color with Section 262726 "Wiring Devices."
2. For use with snap-in jacks accommodating any combination of twisted pair, optical-fiber, and coaxial work area cords.
 - a. Flush-mounted jacks, positioning the cord at a 90-degree angle from faceplate surface.
3. Legend:
 - a. Snap-in, clear-label covers and machine-printed paper inserts.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Routing:

1. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

- B. 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 PATHWAYS

- A. Comply with requirements for demarcation point, cabinets, and racks specified in Section 271100 "Communications Equipment Room Fittings."
- B. Comply with Section 270528 "Pathways for Communications Systems."
- C. Comply with Section 270529 "Hangers and Supports for Communications Systems."
- D. Comply with Section 270536 "Cable Trays for Communications Systems."
- E. Drawings indicate general arrangement of pathways and fittings.

3.3 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** 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. MUTOA shall not be used as a cross-connect point.
7. 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** from communications equipment room.
8. 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.
9. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
10. 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.
11. 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.
12. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
13. In the communications equipment room, install a **10-foot-** long service loop on each end of cable.
14. 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.

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 **6 feet** 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 inches**.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches**.
 - 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 inches**.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of **6 inches**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches**.
 - 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 inches**.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches**.
 - 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches**.
 - 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of **5 inches**.

3.4 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.

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 6 feet long not less than 12 inches in diameter below each feed point.

E. Group connecting hardware for cables into separate logical fields.

3.5 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.6 GROUNDING

- A. Comply with requirements in Section 270526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- C. Comply with TIA-607-B and NECA/BICSI-607.
- D. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to

suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.

- E. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
 - 1. Administration Class: 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 4 level of administration.
- 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** 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. 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.

3.8 FIELD QUALITY CONTROL

- A. Field tests and inspections must be witnessed by authorities having jurisdiction.

- B. Tests and Inspections:

- 1. 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.
- 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
- 3. 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.
 - a. 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.
- 4. 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.
- 5. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
- 6. Optical Fiber Cable Tests:
 - a. 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.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and Multimode Horizontal Link Measurements: Test at 850 or 1300 nm in one direction according to TIA-526-14-B, Method B, One Reference Jumper.
 - 2) Attenuation test results for horizontal 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.

- C. 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.

D. Nonconforming Work:

1. End-to-end cabling will be considered defective if it does not pass tests and inspections.
2. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

E. Collect, assemble, and submit test and inspection reports.

F. Manufacturer Services:

1. Engage factory-authorized service representative to support field tests and inspections.

3.9 MAINTENANCE

A. Software Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software service agreement includes software support for two years.
2. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.
 - a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
3. Upgrade Reports: Prepare report after each update, documenting upgrades installed.

END OF SECTION 271513

SECTION 275119 - SOUND MASKING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Networked sound masking systems.
2. Standalone sound masking systems.

B. Products Installed, but Not Furnished, under This Section:

1. See Section 260553 "Identification for Electrical Systems" for electrical equipment.

C. Related Requirements:

1. Section 260011 "Facility Performance Requirements for Electrical" for seismic-load, wind-load, acoustical, and other field conditions applicable to Work specified in this Section.
2. Section 270010 "Supplemental Requirements for Communications" for additional abbreviations, definitions, submittals, qualifications, testing agencies, and other Project requirements applicable to Work specified in this Section.

1.2 DEFINITIONS

A. FACU: Fire-alarm control unit.

B. N.O.: Normally open.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Coordination Meeting(s): For sound masking systems. Conduct meeting(s) at Project site before beginning installation.

1. Attendees: Installers, fabricators, representatives of manufacturers, and administrators for field tests and inspections. Notify Architect, Construction Manager, and Owner's Commissioning Authority of scheduled meeting dates.

1.4 SUBMITTALS

A. Product Data:

1. Networked sound masking systems.
2. Standalone sound masking systems.

- B. Shop Drawings:
 - 1. Shop drawings for sound masking systems.
- C. Field quality-control reports.
- D. Sustainable design submittals.
- E. Manufacturers' Published Instructions:
 - 1. Networked sound masking systems.
 - 2. Standalone sound masking systems.
- F. Field Reports:
 - 1. Manufacturer's field reports for field quality-control support.
 - 2. Manufacturer's field reports for system startup support.
 - 3. Field reports for software and firmware upgrades.
- G. Warranty documentation.
- H. Sustainable design closeout documentation.
- I. Spare Parts:
 - 1. UL AZOT - Networked sound masking system.
 - 2. UL UEAY - Standalone sound masking loudspeakers.
 - 3. UL AZOT - Single-room sound masking system.
- J. Extra Stock Material:
 - 1. UL AZOT - Networked sound masking system.
 - 2. UL UEAY - Standalone sound masking loudspeakers.
 - 3. UL AZOT - Single-room sound masking system.
- K. Special Tools:
 - 1. UL AZOT - Networked sound masking system.
 - 2. UL UEAY - Standalone sound masking loudspeakers.
 - 3. UL AZOT - Single-room sound masking system.

1.5 REGULATORY AGENCY APPROVALS

- A. Submittals for sound masking systems connected to fire alarm and mass notification require approval by authorities having jurisdiction and must be signed and sealed by qualified life safety professional engineer responsible for their preparation. Obtain approval by authorities having jurisdiction prior to submitting for action by Architect.

1.6 WARRANTY FOR SOUND MASKING SYSTEMS

- A. Special Installer Extended Warranty: Installer warrants that fabricated and installed sound masking systems perform in accordance with specified requirements and agrees to repair or replace components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: Four years from date of Substantial Completion; full coverage for labor, materials, and equipment.
- B. Special Manufacturer Extended Warranty: Manufacturer warrants that sound masking systems perform in accordance with specified requirements and agrees to provide repair or replacement of components or products that fail to perform as specified within extended-warranty period.
 - 1. Extended-Warranty Period: Ten years from date of Substantial Completion; full coverage for materials only, free on board destination, freight prepaid.

PART 2 - PRODUCTS

2.1 NETWORKED SOUND MASKING SYSTEMS

- A. Description: Electronic noise generators and associated controls for simultaneously operating multiple loudspeakers throughout facility.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. General Characteristics:
 - a. Reference Standards: Complies with principles and recommended test methods described in ASTM E1374.
- C. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
 - a. Include construction details, material descriptions, dimensions, profiles, and finishes of individual components.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - c. Include certificate of listing and approved markings from qualified electrical testing laboratory for plenum-mounted and rack-mounted equipment.
 - d. Include sample warranty language.
 - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

D. UL AZOT - Networked Sound Masking System:

1. Basis of Design
 - a. Cambridge/Biamp Qt X Series
2. Source Limitations: Obtain products from single manufacturer.
3. Listing Criteria:
 - a. Audio Equipment: Comply with one of the following:
 - 1) UL CCN AZOT; including UL 62368-1.
 - 2) UL CCN AZSQ; including UL 60065 or UL 6500.
 - 3) UL CCN AZJX; including UL 813.
 - b. Suitable for Installation in Air-Handling Spaces: UL CCN BHZF; including UL 2043.
4. Options:
 - a. Loudspeaker Mounting: Ceiling.
 - b. Network Control Panel Mounting: Rack.
 - c. Provide input for connection to supervised fire-alarm N.O. contact that when closed causes network controller to mute paging, background music, and other audio programming.
 - d. Masking Sound Frequency Range: 20 Hz to 20 kHz, with equalizers for adjusting the masking sound spectrum at third-octave resolution.
 - e. Masking Sound Volume Adjustment: Digital control, adjustable in 0.5 dB increments over the range of 34 to 82.5 dB(A-weighted), or a continuous adjustment within that range.
 - f. Masking Preset Contour Options: 50.
 - g. Paging Inputs: Provision for connecting microphone, telephone, and auxiliary audio device with analog-to-digital conversion of audio signals.
 - h. Remote central volume control.
5. Accessories:
 - a. Spare Parts: Furnish to Owner spare parts, for repairing sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.
 - b. Extra Stock Material: Furnish to Owner extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - c. Special Tools: Furnish to Owner proprietary equipment, keys, and software required to operate, maintain, repair, adjust, or implement future changes to sound masking equipment, that are packaged with protective covering for storage on-site and identified with labels describing contents.

2.2 STANDALONE SOUND MASKING SYSTEMS

- A. Description: Self-contained loudspeaker with electronic noise generator and associated controls.
- B. Performance Criteria:
 - 1. Regulatory Requirements: Listed and labeled in accordance with NFPA 70, by qualified electrical testing laboratory recognized by authorities having jurisdiction, and marked for intended location and application.
 - 2. General Characteristics:
 - a. Reference Standards: Complies with principles and recommended test methods described in ASTM E1374.
- C. Source Quality Control:
 - 1. Product Data: Prepare and submit catalog cuts, brochures, and performance data illustrating size, physical appearance, and other characteristics of product.
 - a. Include construction details, material descriptions, dimensions, profiles, and finishes of individual components.
 - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - c. Include certificate of listing and approved markings from qualified electrical testing laboratory for plenum-mounted and rack-mounted equipment.
 - d. Include sample warranty language.
 - 2. Manufacturer's Published Instructions: Prepare and submit installation, testing, and operating instructions for product.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Shop Drawings: Prepare and submit the following:
 - 1. Shop Drawings for Sound Masking Systems:
 - a. Include plans, elevations, sections, details, and attachments to other work.
 - b. Include schematic of system and floor plan indicating quantity, type, and location of components.
 - c. Include diagrams for power, signal, and control wiring.
 - d. Include details supplementing assembly and installation instructions with dimensions, weights, loads, required clearances, methods of field assembly, components, and location and rating of each field connection.
- B. Sustainable Design Submittals: Prepare and submit documentation for the following:
 - 1. [<Double click to insert sustainable design text for Acoustic Performance>](#)

3.2 INSTALLATION OF SOUND MASKING SYSTEMS

- A. Comply with manufacturer's published instructions.
- B. Reference Standards for Installation:
 - 1. Audio Equipment and Wiring Methods: Unless more stringent requirements are specified in Contract Documents or manufacturers' published instructions, comply with Article 640 of NFPA 70.
 - 2. Consult Architect for resolution of conflicting requirements.
- C. Special Installation Techniques:
 - 1. Loudspeaker Installation above Ceiling: Suspend with chains from building structure above ceilings, so bottom of assembly is **6 to 8 inch** above upper plane of finished ceiling material. Use eyebolts on speaker assemblies for attachment. Suspend independently from structure, not to supports for components of other building systems.
 - 2. Zoned Loudspeaker Connections: For two- or three-channel systems, connect loudspeaker assemblies alternatively, so masking sound is redundant throughout coverage zones.
 - 3. Wiring Methods:
 - a. Cable in Raceway: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and unless otherwise indicated.
 - 1) Except raceways are not required in accessible indoor ceiling spaces and attics.
 - 2) Except raceways are not required in hollow gypsum board partitions.
 - 3) Conceal raceways and wiring, except in unfinished spaces.
 - b. Concealed Cable: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - c. Exposed Cable: Install parallel to building lines, follow surface contours, and support as recommended by manufacturer.
 - 1) Install plenum cable in environmental air-handling spaces, including plenum ceilings.
 - d. Within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
 - 4. Grounding: As recommended by manufacturers unless more stringent requirements are indicated. Ground equipment and conductors to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments with a maximum of 5 Ω to ground at main equipment location. Measure, record, and report ground resistance.
 - 5. Impedance Matching: For system components, including connecting cable, provide end-to-end level and impedance-matched signal paths. Use matching networks and balancing devices at connections where necessary to avoid mismatches.

6. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
7. Identification: Provide labels for vehicle charging equipment and associated electrical equipment.
 - a. Use color-coded conductors, and apply wire- and cable-marking tape to designate wires and cables, so media are identified in coordination with system wiring diagrams.
 - b. Label loudspeakers as to channel, zone, and address.
 - c. Identify field-installed conductors, interconnecting wiring, and components.
 - d. Provide warning signs.
 - e. Label each enclosure with engraved metal or laminated-plastic nameplate.

D. Interfaces with Other Work:

1. Coordinate quantity and arrangement of sound masking system components with ceiling space configuration and with components occupying ceiling space, including structural members, pipes, air-distribution components, raceways, cable trays, luminaires, and other items.
2. Coordinate with Section 270528 "Pathways for Communications Systems" for raceway system material, routing, and locations.
3. Coordinate with Section 260533.13 "Conduit for Electrical Systems" for installation of raceways.
4. Coordinate with Section 260533.16 "Boxes and Covers for Electrical Systems" for installation of boxes.
5. Coordinate with Section 271513 "Communications Copper Horizontal Cabling" for installation of network cabling, loudspeaker cabling, and Class 2 control cabling.
6. Final connection to FACU will be completed by fire-alarm system installer.

E. Systems integration.

3.3 FIELD QUALITY CONTROL OF SOUND MASKING SYSTEMS

A. Acceptance Testing Preparation:

1. Pretesting: Tune, align, and adjust system, and pretest components, wiring, and functions to verify compliance with specified material, installation, and performance requirements. Correct deficiencies and retest until satisfactory performance and conditions are achieved.

B. Field tests and inspections must be witnessed by authorities having jurisdiction.

C. Tests and Inspections:

1. Perform manufacturer's recommended tests and inspections.
2. Operational Test: Start system to confirm proper operation. Remove malfunctioning units, replace with new units, and retest. Make initial sound-spectrum and -level adjustments for each zone.

3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 4. Masking Sound Power Level Adjustments: Adjust independently for each space to minimum level between 40 and 50 dB(A-weighted) that will provide speech privacy between adjacent workstations while complying with other system requirements.
- D. Final Acceptance Testing: Provide a minimum of 10 days' notice of acceptance test performance schedule. Schedule tests after pretesting has been successfully completed.
1. Perform sound masking evaluation tests in accordance with ASTM E1130, with measurements and calculations in accordance with ASA S3.5.
 2. Tests and Calibration Conditions: Spaces are to be completely furnished, but unoccupied; lights and HVAC systems must be on; HVAC system testing and balancing are to be completed; and electronic ballasts, lighting relay panels, and low-voltage transformers must be in place.
 3. Test Conditions: Complying with ASTM E1130 and calculated in accordance with ASA S3.5.
 4. Instrumentation: Use a professional-quality, sound-level meter with octave-band filters and documentation of recent calibration against recognized standards. Comply with ASA S1.4 Part 1.
 5. System Tests: Include the following for each system zone:
 - a. Loudspeaker Circuit Impedance Test: Measure impedance at 1000 Hz with amplifier disconnected, using a professional impedance meter or bridge. Locate and correct faults denoted by abnormal readings.
 - b. Ambient Sound-Level Tests: With system off, measure ambient sound level in one-third octave bands. Also measure ambient sound level as a single, wide-band, A-weighted reading.
 - c. System Noise Test: With masking-noise signal on and amplifiers adjusted at a working level 10 dB above ambient sound level, check for hum, buzz, rattle, or other operating deficiencies.
 - d. Spatial Uniformity Test: Measure sound level at locations no greater than 15 ft on center throughout covered spaces to determine compliance with specified performance level.
 - e. Frequency Response Adjustment and Test: Adjust one-third octave frequency bands and other unit filters to provide response. Adjust to meet requirement of space speech intelligibility and quality of background sound. Comply with ASA S3.2, CTA-426, and ASTM E1110.
 6. Adjust level of masking sound that is appropriate for area and overall volume.
 7. Walk-Through Test: People in covered spaces cannot discern loudspeaker locations.
- E. Record test observations, readings, and corrective actions. Report test results in accordance with ASTM E1130.
- F. Record final control settings and programming, and final tap setting of loudspeaker-matching transformers. Record final sound-level measurements and observations.
- G. Nonconforming Work:
1. Units will be considered defective if they do not pass tests and inspections.

2. Remove and replace defective units and retest.

H. Field Quality-Control Reports: Collect, assemble, and submit test and inspection reports.

I. Manufacturer Services: Engage factory-authorized service representative to support field tests and inspections.

1. Manufacturer's Field Reports for Field Quality-Control Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.4 SYSTEM STARTUP

A. Perform startup service.

1. Complete installation and startup checks in accordance with manufacturer's published instructions.

B. Manufacturer Services: Engage factory-authorized service representative to support system startup.

1. Manufacturer's Field Reports for System Startup Support: Prepare and submit report after each visit by factory-authorized service representative, documenting activities performed at Project site.

3.5 ADJUSTING

A. Sound Masking Adjustments: Adjust sound masking devices to suit actual occupied conditions.

3.6 PROTECTION

A. After installation, protect sound masking equipment from construction activities. Remove and replace items that are contaminated, defaced, damaged, or otherwise caused to be unfit for use prior to acceptance by Owner.

3.7 MAINTENANCE

A. Sound Masking Readjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in readjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

B. Software and Firmware Service Agreement:

1. Technical Support: Beginning at Substantial Completion, verify that software and firmware service agreement includes software and firmware support for two years.
2. Upgrade Service: At Substantial Completion, update software and firmware to latest version. Install and program software and firmware upgrades that become available

within two years from date of Substantial Completion. Verify that upgrading software includes operating system and new or revised licenses for using software.

- a. Upgrade Notice: No fewer than 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.
3. Field Reports for Software and Firmware Upgrades: Prepare and submit report after each update, documenting upgrades installed.

END OF SECTION 275119

SECTION 280010 – SUPPLEMENTAL REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Supplemental requirements generally applicable to the Work specified in Division 28.

B. Related Requirements:

1. Section 260010 "Supplemental Requirements for Electrical" for abbreviations and acronyms for electrical terms and units of measure, abbreviations and acronyms for electrical raceway types, abbreviations and acronyms for electrical cable types, and additional coordination drawing submittal requirements.

1.2 REFERENCES

A. Abbreviations and Acronyms for Electronic Safety and Security:

1. BMS: Building management system.
2. FACU: Fire-alarm control unit.
3. PoE: Power over Ethernet.
4. POTS: Plain old telephone service. See "public switched telephone network."
5. TCP/IP: Transmission control protocol/Internet protocol.

B. Definitions for Electronic Safety and Security:

1. Voice over Internet Protocol (VoIP): Digital telephone packet technology that uses the internet for its transmission medium.

1.3 INFORMATIONAL SUBMITTALS

1. Seismic-Load Performance Certificates: Provide special certification as required for designated seismic-load systems identified in the Specifications.
 - a. The following systems and components are designated seismic-load systems requiring written special certification of seismic qualification by manufacturer:
 - 1) FACUs and their battery backup specified in Section 284621.11 "Addressable Fire-Alarm Systems."

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data:

1. Provide emergency operation, normal operation, and preventive maintenance manuals for each system, equipment, and device listed below:
 - a. Addressable Fire-Alarm Systems.
2. Include the following information:
 - a. Manufacturer's operating specifications.
 - b. User's guides for software and hardware.
 - c. Schedule of maintenance material items recommended to be stored at Project site.
 - d. Detailed instructions covering operation under both normal and abnormal conditions.
 - e. Manufacturer's instructions for setting field-adjustable components.
 - f. Manufacturer's instructions for testing, adjusting, and reprogramming microprocessor controls.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 INSTALLATION OF ELECTRONIC SAFETY AND SECURITY WORK

- A. Unless more stringent requirements are specified in the Contract Documents or manufacturers' instructions, comply with NFPA 70, NFPA 72, NFPA 731, and NECA NEIS 1 for installation of Work specified in Division 28. Consult Architect for resolution of conflicting requirements.

END OF SECTION 280010

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fire-alarm control unit.
 - 2. Manual fire-alarm boxes.
 - 3. System smoke detectors.
 - 4. Air-sampling smoke detectors.
 - 5. Heat detectors.
 - 6. Notification appliances.
 - 7. Remote annunciator.
 - 8. Addressable interface device.
 - 9. Digital alarm communicator transmitter.
 - 10. Radio alarm transmitter.
 - 11. Network communications.

1.3 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 - a. Show field wiring required for HVAC unit shutdown on alarm.
 - b. Locate detectors according to manufacturer's written recommendations.
11. Include floor plans showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified, fire-alarm technician; Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. Include the following and deliver copies to authorities having jurisdiction:
 - a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
 - d. Riser diagram.
 - e. Device addresses.
 - f. Record copy of site-specific software.
 - g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
 - h. Manufacturer's required maintenance related to system warranty requirements.
 - i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL (nationally recognized testing laboratory).

1.8 PROJECT CONDITIONS

- A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 - 2. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and horn/strobe evacuation.
- B. Automatic sensitivity control of certain smoke detectors.
- C. All components provided shall be listed for use with the selected system.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
 - 1. Manual stations.
 - 2. Heat detectors.
 - 3. Smoke detectors.
 - 4. Duct smoke detectors.
 - 5. Automatic sprinkler system water flow.
- B. Fire-alarm signal shall initiate the following actions:
 - 1. Continuously operate alarm notification appliances.

2. Identify alarm and specific initiating device at fire-alarm control unit, and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
5. Activate emergency shutoffs for gas and fuel supplies.
6. Record events in the system memory.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Alert and Action signals of air-sampling detector system.
3. User disabling of zones or individual devices.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, or remote annunciator.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.
6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.

E. System Supervisory Signal Actions:

1. Initiate notification appliances at fire alarm control unite and remote annunciators.
2. Identify specific device initiating the event at fire-alarm control unit[, and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

A. Equipment shall be Silent Knight 5820XL or Notifier NFS2-3030, as manufactured and supplied by Honeywell Fire Systems. Maximum number of devices on a circuit shall not exceed 80% of the rated capacity of the circuit. Unless otherwise indicated; the system shall be the standard product of one manufacturer and shall be factory coordinated/

- B. Systems as manufactured by Fire-Lite, equal to those specified and approved by the Engineer, will be acceptable. Manufacturer shall submit to engineer prior to bidding proposed equipment list.
- C. General Requirements for Fire-Alarm Control Unit:
 - 1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer.
 - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
 - d. The FACP shall be listed for connection to a central-station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
 - 2. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- D. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 - 1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- E. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 - 1. Annunciator and Display: Liquid-crystal type, four line(s) of 20 characters, minimum.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
- F. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
 - 1. Pathway Class Designations: NFPA 72, Class B.
 - 2. Install no more than 100 addressable devices on each signaling-line circuit.
 - 3. Serial Interfaces:
 - a. One dedicated RS 485 port for remote station operation using point ID DACT.
 - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).

- c. One RS 232 port for PC configuration.

G. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Sound general alarm if the alarm is verified.
4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

H. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals supervisory and digital alarm communicator transmitters and digital alarm radio transmitters shall be powered by 24-V dc source.

1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead acid

M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 MANUAL FIRE-ALARM BOXES

A. Manual fire-alarm boxes shall be as manufactured by Silent Knight.

B. Manual fire-alarm boxes as manufactured by Fire-Lite, equal to those specified and approved by the Engineer, will be acceptable.

- C. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 - 2. Station Reset: Key- or wrench-operated switch.
 - 3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
 - 4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.6 SYSTEM SMOKE DETECTORS

- A. System smoke detectors shall be as manufactured by Silent Knight.
- B. System smoke detectors as manufactured by Fire-Lite, equal to those specified and approved by the Engineer, will be acceptable.
- C. General Requirements for System Smoke Detectors:
 - 1. Comply with UL 268; operating at 24-V dc, nominal.
 - 2. Detectors shall be two-wire type.
 - 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - 5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
 - 7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition.
 - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 deg F per minute.
 - b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 deg F.
 - c. Multiple levels of detection sensitivity for each sensor.
 - d. Sensitivity levels based on time of day.
- D. Photoelectric Smoke Detectors:
 - 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

E. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.7 HEAT DETECTORS

- A. Heat detectors shall be as manufactured by Silent Knight.
- B. Heat detectors as manufactured by Fire-Lite, equal to those specified and approved by the Engineer, will be acceptable.
- C. General Requirements for Heat Detectors: Comply with UL 521.
 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- D. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or a rate of rise that exceeds 15 deg F per minute unless otherwise indicated.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- E. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 135 deg F.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.8 NOTIFICATION APPLIANCES

- A. Notification appliances shall be as manufactured by System Sensor.
- B. Notification appliances as manufactured by Cooper-Wheelock, equal to those specified and approved by the Engineer, will be acceptable.
- C. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.
 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- D. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
- E. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch high letters on the lens.
 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall mounted unless otherwise indicated.
 3. Flashing shall be in a temporal pattern, synchronized with other units.
 4. Strobe Leads: Factory connected to screw terminals.
 5. Mounting Faceplate: Factory finished, white.
- F. Addressable Relay Modules:
 1. Provide address-setting means on the module. Store an internal identifying code for control panel use to identify the module type.
 2. Allow the control panel to switch the relay contacts on command.
 3. Have a minimum of two normally open and two normally closed contacts available for field wiring.
 4. Listed for controlling HVAC fan motor controllers.

2.9 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

- A. General:
 1. Include address-setting means on the module.
 2. Store an internal identifying code for control panel use to identify the module type.
 3. Listed for controlling HVAC fan motor controllers.
- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
 1. Allow the control panel to switch the relay contacts on command.
 2. Have a minimum of two normally open and two normally closed contacts available for field wiring.
- D. Control Module:
 1. Operate notification devices.
 2. Operate solenoids for use in sprinkler service.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone lines and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 1. Verification that both telephone lines are available.
 2. Programming device.
 3. LED display.
 4. Manual test report function and manual transmission clear indication.
 5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 RADIO ALARM TRANSMITTER

A. Transmitter shall comply with NFPA 1221 and 47 CFR 90.

B. Description: Manufacturer's standard commercial product; factory assembled, wired, and tested; ready for installation and operation.

1. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
2. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
3. Normal Power Input: 120-V ac.
4. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
5. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph with a gust factor of 1.3 without failure.
6. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
7. Antenna-Cable Connectors: Weatherproof.
8. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.

C. Functional Performance: Unit shall receive alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:

1. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.

2. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
3. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
4. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
5. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
6. Local Fire-Alarm-System, Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches above the finished floor.
 1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Manual Fire-Alarm Boxes:
 1. Install manual fire-alarm box in the normal path of egress within 60 inches of the exit doorway.
 2. Mount manual fire-alarm box on a background of a contrasting color.

3. The operable part of manual fire-alarm box shall be between 42 inches and 48 inches above floor level. All devices shall be mounted at the same height unless otherwise indicated.

D. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
3. Smooth ceiling spacing shall not exceed 30 feet.
4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches from air-supply diffuser or return-air opening.
6. Lighting Fixtures: Locate detectors not closer than 12 inches from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

- E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

- F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

- G. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

- H. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

- I. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling. Install all devices at the same height unless otherwise indicated.

- J. Device Location-Indicating Lights: Locate in public space near the device they monitor.

- K. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph wind load with a gust factor of 1.3 without damage.

3.3 PATHWAYS

- A. Pathways above recessed ceilings and in non-accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches above the floor shall be installed in EMT.

- B. Pathways shall be installed in EMT.

3.4 CONNECTIONS

- A. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Smoke dampers in air ducts of designated HVAC duct systems.
 - 2. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 - 3. Supervisory connections at valve supervisory switches.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections.
- D. Perform the following 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 the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for one year.
- C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within one year from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION 283111

SECTION 311000 - SITE CLEARING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Protecting existing vegetation to remain.
 - 2. Removing existing vegetation.
 - 3. Clearing and grubbing.
 - 4. Stripping and stockpiling topsoil.
 - 5. Removing above- and below-grade site improvements.
 - 6. Disconnecting, capping or sealing, and removing site utilities.
 - 7. Temporary erosion- and sedimentation-control measures.

1.3 DEFINITIONS

- A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- B. 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.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.
- D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
- E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 MATERIAL OWNERSHIP

- A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
 - 1. Use sufficiently detailed photographs or videotape.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.
- B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Notify "One Call" for area where Project is located before site clearing.
- C. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
- D. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- E. Do not direct vehicle or equipment exhaust towards protection zones.
- F. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.
- G. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
 - 1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Locate and clearly identify trees, shrubs, and other vegetation to remain. Flag each tree trunk at breast height.
- C. Protect existing site improvements to remain from damage during construction.
 - 1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and Storm Water Pollution Prevention Plan (SWPPP).
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. General: Protect trees and plants remaining on-site according to requirements on the Drawings.

- B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Landscape Architect.

3.4 EXISTING UTILITIES

- A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.
 - 1. Arrange with utility companies to shut off indicated utilities.
- B. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- C. Excavate for and remove underground utilities indicated to be removed.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
 - 3. Use only hand methods for grubbing within protection zones.
 - 4. Chip removed tree branches and dispose of off-site.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to depth of 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
 - 1. Limit height of topsoil stockpiles to 72 inches.
 - 2. Do not stockpile topsoil within protection zones.

3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.

3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
 2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

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. Geotechnical Engineering Report; provided with project handbook.

1.2 SUMMARY

- A. Section Includes:
 - 1. Preparing subgrades for slabs-on-grade, walks, and pavements.
 - 2. Excavating and backfilling for buildings and structures.
 - 3. Drainage course for concrete slabs-on-grade.
 - 4. Subbase course for concrete walks and pavements.
 - 5. Subbase course for asphalt paving.
 - 6. Subsurface drainage backfill for walls and trenches.
 - 7. Excavating and backfilling trenches for utilities and pits for buried utility structures.
- B. Related Sections:
 - 1. Section 311000 "Site Clearing" for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.

1.3 DEFINITIONS

- A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
- D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

- E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
- G. Fill: Soil materials used to raise existing grades.
- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.4 SUBMITTALS

- A. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487.
 - 2. Laboratory compaction curve according to ASTM D 698.

1.5 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Notify "One Call" for area where Project is located before beginning earth moving operations.
- C. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Section 311000 "Site Clearing" are in place.
- D. Do not commence earth moving operations until plant-protection measures specified on the plans are in place.

- E. The following practices are prohibited within protection zones:
1. Storage of construction materials, debris, or excavated material.
 2. Parking vehicles or equipment.
 3. Foot traffic.
 4. Erection of sheds or structures.
 5. Impoundment of water.
 6. Excavation or other digging unless otherwise indicated.
 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- F. Do not direct vehicle or equipment exhaust towards protection zones.
- G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, GC, SW, SP, SM, and SC according to ASTM D 2487, in acceptable locations as directed in the Geotechnical Report for the Project; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter. Soil Classification Groups CL and CH according to ASTM D 2487 can be considered marginally satisfactory as directed in the Geotechnical Report for the Project. The following criteria shall apply to the low volume change (LVC) material placed below the building floor slabs.
1. Liquid Limit: <50.
 2. Plasticity Index: <23.
- C. Unsatisfactory Soils: Soil Classification Groups ML, OL, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
1. Unsatisfactory soils also include satisfactory soils not maintained to 0-4 percent above the optimum moisture content at time of compaction for clay soils with a liquid limit greater than 40 and within 2 percent of optimum moisture content at time of compaction for clay soils with a liquid limit less than 40.
- D. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.

- E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch (37.5-mm) sieve and not more than 12 percent passing a No. 200 (0.075-mm) sieve.
- G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.
- H. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.
- I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.
- J. Sand: ASTM C 33; fine aggregate.
- K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 ACCESSORIES

- A. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility; colored as follows:
 - 1. Red: Electric.
 - 2. Yellow: Gas, oil, steam, and dangerous materials.
 - 3. Orange: Telephone and other communications.
 - 4. Blue: Water systems.
 - 5. Green: Sewer systems.

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 earth moving operations.

- B. Protect and maintain erosion and sedimentation controls during earth moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
 - 2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
 - a. 24 inches outside of concrete forms other than at footings.
 - b. 12 inches outside of concrete forms at footings.
 - c. 6 inches outside of minimum required dimensions of concrete cast against grade.
 - d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
 - e. 6 inches beneath bottom of concrete slabs-on-grade.
 - f. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

3.4 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
 - 1. Excavations for Footings and Foundations: Excavate to provide 24 inches low volume change material per the Geotechnical Report for the Project

2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

3.5 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.6 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

- C. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

- D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.

3.7 SUBGRADE INSPECTION

- A. Notify Geotechnical Engineer when excavations have reached required subgrade.

- B. If Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 25 tons to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 - 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
 - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Engineer, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Geotechnical Engineer, without additional compensation.

3.8 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 3500 psi, may be used when approved by Structural Engineer.
 - 1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Engineer.

3.9 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 BACKFILL

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

4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

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

3.11 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill voids with satisfactory soil while removing shoring and bracing.
- D. Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.
 1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
- E. Place and compact final backfill of satisfactory soil to final subgrade elevation.
- F. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.12 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 1. Under grass and planted areas, use satisfactory soil material.
 2. Under walks and pavements, use satisfactory soil material.
 3. Under steps and ramps, use satisfactory soil material.
 4. Under building slabs, use engineered fill.
 5. Under footings and foundations, use satisfactory soil material.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.13 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content for clay soils with a

liquid limit less than 40 and 0-4 percent above optimum moisture content for clay soils with a liquid limit greater than 40.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content limits described above and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry density according to ASTM D 698:
 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 8 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 95 percent.
 3. For areas below landscaped surfaces, compact each layer of initial and final backfill soil material at 90 percent.

3.15 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
 1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 1. Turf or Unpaved Areas: Plus or minus 1 inch.
 2. Walks: Plus or minus 1 inch.
 3. Pavements: Plus or minus 1/2 inch.
- C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.16 SUBBASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place subbase course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase course under pavements and walks as follows:
 - 1. Place base course material over subbase course under hot-mix asphalt pavement.
 - 2. Shape subbase course to required crown elevations and cross-slope grades.
 - 3. Place subbase course 6 inches or less in compacted thickness in a single layer.
 - 4. Compact subbase course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry density according to ASTM D 698.

3.17 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Place drainage course 6 inches or less in compacted thickness in a single layer.
 - 2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry density according to ASTM D 698.

3.18 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 - 2. Determine that fill material and maximum lift thickness comply with requirements.
 - 3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
 - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
 - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.19 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Engineer; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. END OF SECTION 312000

SECTION 313116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Prime Agreement, including General and Supplementary Conditions, when referenced by the Prime Agreement, and other Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. Section Includes:
 - 1. Soil treatment with termiticide.
- B. Related Sections:
 - 1. Division 06 Section "Rough Carpentry" for wood preservative treatment by pressure process.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of termite control product.
 - 1. Include the EPA-Registered Label for termiticide products.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Product Certificates: For termite control products, from manufacturer.
- C. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
 - 1. Date and time of application.
 - 2. Moisture content of soil before application.
 - 3. Termiticide brand name and manufacturer.
 - 4. Quantity of undiluted termiticide used.
 - 5. Dilutions, methods, volumes used, and rates of application.
 - 6. Areas of application.
 - 7. Water source for application.
- D. Warranties: Sample of special warranties.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located.
- B. Regulatory Requirements: Formulate and apply termiticides and termiticide devices according to the EPA-Registered Label.
- C. Source Limitations: Obtain termite control products from single source from single manufacturer.

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
- B. Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.

1.7 WARRANTY

- A. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.

- 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SOIL TREATMENT

- A. Termiticide: Provide an EPA-Registered termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. BASF Corporation, Agricultural Products; Termidor.
 - b. Bayer Environmental Science; Premise 75.
 - 2. Service Life of Treatment: Soil treatment termiticide that is effective for not less than five years against infestation of subterranean termites.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label requirements, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
- B. Proceed with application only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
- B. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
 - 1. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

3.3 APPLICATION, GENERAL

- A. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.

3.4 APPLYING SOIL TREATMENT

- A. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute treatment evenly.
 - 1. Slabs-on-Grade and Basement Slabs: Underground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
 - 2. Foundations: Adjacent soil, including soil along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.

- B. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
- C. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.
- D. Post warning signs in areas of application.
- E. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

END OF SECTION 313116

SECTION 321216 - ASPHALT 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.
- B. Kansas City Metropolitan Chapter of the American Public Works Association Construction and Material Specifications Section 2200 Paving; Adopted February 15, 2017 (APWA Section 2200).

1.2 SUMMARY

- A. Section Includes:
 - 1. Hot-mix asphalt patching.
 - 2. Hot-mix asphalt paving.
 - 3. Pavement-marking paint.
- B. Related Sections:
 - 1. Section 312000 "Earth Moving" for aggregate subbase and base courses.

1.3 DEFINITION

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
 - 1. Job-Mix Designs: For each job mix proposed for the Work.

1.5 INFORMATIONAL SUBMITTALS

- A. Material Certificates: For each paving material, from manufacturer.
- B. Material Test Reports: For each paving material.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
- B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
 - 1. Prime Coat: Minimum surface temperature of 60 deg F.
 - 2. Tack Coat: Minimum surface temperature of 60 deg F.
 - 3. Slurry Coat: Comply with weather limitations in ASTM D 3910.
 - 4. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 - 5. Asphalt Surface Course: Minimum surface temperature of 60 deg F at time of placement.
- B. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. General: Use materials and gradations that have performed satisfactorily in previous installations.
- B. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- C. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, PG 64-22.

2.3 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than 45 minutes.

1. Color: As indicated on the plans.

- B. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 6-1/2 inches high by 8 inches wide by 84 inches long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 3/4-inch diameter, 30-inch minimum length.

2.4 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes proving APWA Section 2200 complaint mix designs.

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Provide mixes complying with composition, grading, and tolerance requirements in ASTM D 3515 for the following nominal, maximum aggregate sizes:
 - a. Base Course: 1-1/2 inch.
 - b. Surface Course: 3/4 inch.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that subgrade is dry and in suitable condition to begin paving.
- B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
 1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.

2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 25 tons.
 3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 PATCHING

- A. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.
- B. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of 0.05 to 0.15 gal./sq. yd.
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.
- C. Patching: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.3 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

3.4 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
 2. Place hot-mix asphalt surface course in single lift.
 3. Spread mix at minimum temperature of 250 deg F.
 4. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
 5. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
 - 1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.5 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
 - 1. Clean contact surfaces and apply tack coat to joints.
 - 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. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
 - 5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
 - 6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.6 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.
 - 1. Complete compaction before mix temperature cools to 185 deg F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
 - 1. Average Density: 96 percent of reference laboratory density according to ASTM D 2950 for surface course, and 95 percent of reference laboratory density for base course.

- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
- G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.7 INSTALLATION TOLERANCES

- A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
 - 1. Base Course: Plus or minus 1/2 inch.
 - 2. Surface Course: Plus 1/4 inch, no minus.
- B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course: 1/4 inch.
 - 2. Surface Course: 1/8 inch.

3.8 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Allow paving to age for 7 days before starting pavement marking.
- C. 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 wet film thickness of 15 mils.

3.9 WHEEL STOPS

- A. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
- C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
- D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.
 - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
 - 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.
- E. Replace and compact hot-mix asphalt where core tests were taken.
- F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.11 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
 - 1. Do not allow milled materials to accumulate on-site.

END OF SECTION 321216

SECTION 321313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Kansas City Metropolitan Materials Board (KCMMB) Standard Concrete Specifications

1.2 SUMMARY

- A. Section includes concrete paving including the following:
 - 1. Walks and driveways.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash, slag cement, and other pozzolans.
- B. W/C Ratio: The ratio by weight of water to cementitious materials.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified ready-mix concrete manufacturer, and testing agency.
- B. Material Certificates: For the following, from manufacturer:
 - 1. Cementitious materials.
 - 2. Fiber reinforcement.
 - 3. Admixtures.
 - 4. Curing compounds.
 - 5. Applied finish materials.
 - 6. Bonding agent or epoxy adhesive.
 - 7. Joint fillers.
- C. Material Test Reports: For each of the following:

1. Aggregates: Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.
1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").
- B. Testing Agency Qualifications: Qualified according to ASTM C1077 and ASTM E329 for testing indicated.
1. Personnel conducting field tests must be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.

1.7 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified independent testing agency to perform preconstruction testing on concrete paving mixtures.

1.8 FIELD CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F 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 specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F

- at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE, GENERAL

- A. Sitework concrete shall meet Kansas City Metropolitan Material Board Specifications

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
 1. Use flexible or uniformly curved forms for curves with a radius of 100 feet or less. Do not use notched and bent forms.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 CONCRETE MATERIALS

- A. KCMMB 4K: Sitework concrete shall be KCMMB 4K.

2.4 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182,
- B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.

2.5 RELATED MATERIALS

- A. Joint Fillers: ASTM D1751, asphalt-saturated cellulosic fiber

2.6 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
 - 2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that comply with or exceed requirements.
- B. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement in concrete as follows:
 - 1. Fly Ash or Pozzolan: 25 percent.
 - 2. Slag Cement: 50 percent.
 - 3. Combined Fly Ash or Pozzolan, and Slag Cement: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
- C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
 - 1. Air Content, 1-1/2-inch Nominal Maximum Aggregate Size: 5-1/2 percent plus or minus 1-1/2 percent.
 - 2. Air Content, 1-inch Nominal Maximum Aggregate Size: 6 percent plus or minus 1-1/2 percent.
 - 3. Air Content, 3/4-inch Nominal Maximum Aggregate Size: 6 percent plus or minus 1-1/2 percent.
- D. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- E. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
 - 1. Use high-range, water-reducing admixture, high-range, water-reducing and retarding admixture in concrete as required for placement and workability.
 - 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- F. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd..
- G. Concrete Mixtures: Normal-weight concrete.
 - 1. Compressive Strength (28 Days): 4000 psi.
 - 2. Maximum W/C Ratio at Point of Placement: APWA Kansas City Metro Requirements
 - 3. Slump Limit: APWA Kansas City Metro Requirements
 - 4. Solar Reflectance (SR): Three-year-aged SR value of at least 0.28 or initial SR of at least 0.33.

2.7 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M and ASTM C1116/C1116M. Furnish batch certificates for each batch discharged and used in the Work.
 - 1. When air temperature is between 85 and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.
- B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.
 - 1. For concrete batches of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
 - 2. For concrete batches larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd..
 - 3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subbase surface below concrete paving to identify soft pockets and areas of excess yielding.
 - 1. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to *3 mph*.
 - 2. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons.
 - 3. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.
- B. All utilities that cross under any new roads shall be installed or sleeved prior to final subgrade preparation and construction of pavement structure.

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
- B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 JOINTS

- A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
 - 1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
- B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
 - 1. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
 - 2. Provide tie bars at sides of paving strips where indicated.
 - 3. Butt Joints: Use bonding agent at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
 - 4. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least 1-1/2 inches into concrete.
 - 5. Doweled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.
 - 1. Locate expansion joints at intervals of 50 feet unless otherwise indicated.
 - 2. Extend joint fillers full width and depth of joint.
 - 3. Terminate joint filler not less than 1/2 inch or more than 1 inch below finished surface if joint sealant is indicated.
 - 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 - 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 - 6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

- D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:
 - 1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a 3/8-inch radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
 - a. Tolerance: Ensure that grooved joints are within 3 inches either way from centers of dowels.
 - 2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
 - a. Tolerance: Ensure that sawed joints are within 3 inches either way from centers of dowels.
 - 3. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
- E. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a 1/4-inch radius. Repeat tooling of edges after applying surface finishes. Eliminate edging-tool marks on concrete surfaces.

3.5 CONCRETE PLACEMENT

- A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
- B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- D. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
- F. 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.
- G. Consolidate concrete according to ACI 301 by mechanical vibrating equipment

supplemented by hand spading, rodding, or tamping.

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 reinforcement, dowels, and joint devices.
- H. Screed paving surface with a straightedge and strike off.
- I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleedwater appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
- K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

3.6 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleedwater sheen has disappeared and 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. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
1. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.

3.7 SPECIAL FINISHES

- A. Monolithic Exposed-Aggregate Finish: Expose coarse aggregate in paving surface as follows:
1. Immediately after float finishing, spray-apply chemical surface retarder to paving according to manufacturer's written instructions.
 2. Cover paving surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
 3. Without dislodging aggregate, remove mortar concealing the aggregate by lightly brushing surface with a stiff, nylon-bristle broom. Do not expose more than one-

third of the average diameter of the aggregate and not more than one-half of the diameter of the smallest aggregate.

4. Fine-spray surface with water and brush. Repeat cycle of water flushing and brushing until cement film is removed from aggregate surfaces to depth required.

3.8 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
- E. Curing Methods: Cure concrete by moisture curing, moisture-retaining-cover curing, curing compound, or, a combination of these as follows:
 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.
 - b. Continuous water-fog spray.
 - c. Absorptive cover, water saturated and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorptive covers.

3.9 PAVING TOLERANCES

- A. Comply with tolerances in ACI 117 and as follows:
 1. Elevation: 1/4 inch.
 2. Thickness: Plus 3/8 inch, minus 1/4 inch.
 3. Surface: Gap below 10-feet- long; unleveled straightedge not to exceed 1/2 inch.
 4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches of tie bar.
 5. Lateral Alignment and Spacing of Dowels: 1 inch.
 6. Vertical Alignment of Dowels: 1/4 inch.
 7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches of dowel.
 8. Joint Spacing: 3 inches.
 9. Contraction Joint Depth: Plus 1/4 inch, no minus.
 10. Joint Width: Plus 1/8 inch, no minus.

3.10 REPAIR AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.
- B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
- C. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.

END OF SECTION 321313

SECTION 323100 – GATE OPERATORS

PART 1 – GENERAL

1.1. INCLUDED IN THIS SECTION

- A. Pre-wired, gate operator for horizontal sliding gates, including all selected attachments and accessory equipment.

1.2. RELATED WORK SPECIFIED

- A. Fencing: See section 323119.
- B. Cast in place concrete: See section 033000.
- C. Electrical service and connections: See division 26 series.

1.3. SUBMITTALS

- A. Shop drawings: Submit shop drawings under the provisions of Section 013300. Submit drawings showing connections to adjacent construction, range of travel, and all electrical and mechanical connections to the operator. All underground runs of electrical lines and inductive vehicle obstruction loop locations are shown on the drawings. Provide the necessary the concrete mounting pads and or galvanized mounting posts as needed.
- B. Installation instructions: Submit two copies of manufacturer's installation instructions for this specific project.
- C. Submit manufacturer's completed warranty registration form to architect.
- D. Project list: Submit list of product installations comparable to the subject job. Include date of product installation, installer, and owner's name and location of the project.
- E. Test reports:
 - 1. Submit affidavits from the manufacturer demonstrating that the gate operator mechanism has been tested to 200,000 cycles without breakdown.

1.4. QUALITY ASSURANCE

- A. Manufacturer: A company specializing in the manufacture of gate operators of the type specified, with a minimum of five years' experience manufacturing operators of this type and design.
- B. Installer: Must have a minimum of three years' experience installing similar equipment, provide proof of attending a HySecurity Technical Training within the previous three years, or obtain other significant manufacturer endorsement of technical aptitude, if required, during the submittal process.

1.5. CODES AND REGULATORY REQUIREMENTS

- A. Operators shall be built to UL 325 standards and be listed by a nationally recognized testing laboratory. Complete all electrical work according to local codes and National Electrical Code. All fieldwork shall be performed in a neat and professional manner, completed to journeyman standards.
- B. Current safety standards require the use of multiple external sensors to be capable of reversing the gate in either direction upon sensing an obstruction. See also 2.2F
- C. Vehicular gates should never be used by pedestrians. A separate pedestrian gate must always be provided when foot traffic is present.
- D. Gate must have physical stops to prevent over travel in both the open and close directions.
- E. Current safety standards require gate operators to be designed and labeled for specific usage classes.
 - 1. HySecurity model SlideSmart DC™ HD25 is listed for use in UL 325 Usage Classes: I, II, III, and IV (SlideSmart DC™ HD25 is listed only for use in UL 325 Usage Classes III and IV when speed setting is faster than 1 ft/s).

1.6. PRODUCT DELIVERY AND STORAGE

- A. Comply with 016000.
- B. Store products upright in the original shipping containers, covered, ventilated and protected from all weather conditions.

1.7. WARRANTY

- A. Provide a warranty against all defects in materials or workmanship for five years after the date of installation. Defective materials shall be replaced at the manufacturer's discretion with new or reconditioned materials furnished by the manufacturer, at no cost to the owner. Freight, labor and other incidental costs are not covered under the factory warranty, but may be covered by a separate service agreement between installing company and the owner.

PART 2 – PRODUCTS

2.1. GATE OPERATORS

- A. HySecurity gate operator model SlideSmart DC™ HD25 with Smart DC Controller, or other comparable operator, as approved by the architect or specifier. Substitute operators that are approved will be published in an addendum, not less than ten days prior to bid opening.
- B. Requests for substitutions will be considered.

2.2. OPERATION

- A. Operation shall be by means of a brushed DC electric motor driving a single reduction gear reducer with an output sprocket driving #40 plated roller chain. When the gate is stopped, the motor applies a brake to the drive assembly which inhibits any forced, manual operation of the gate. Gate position is constantly monitored allowing for automatic reposition if motion is detected without the operator receiving a run command. The opening and closing speeds are user adjustable 0.75, 1.0, or 1.25 ft/s (228, 304, or 381 mm/s). Operator shall be capable of handling gates up to 50 ft (15,240 mm) in length weighing up to 2,500 lb (1,134 kg). To accomplish this the operator shall offer 450 lb (204 kg) of rated pull force to the gate. Gate Operator shall operate in the event of a power failure in an uninterruptible power supply mode to the extent the two 8Ah batteries can maintain adequate power.
- B. Minimum standard mechanical components:
 - 1. Two piece lockable metal cover. Cover protects bystanders from pinch hazards of roller chain traveling through idlers and drive sprocket.
 - 2. Chassis to be constructed of 12ga (2.7 mm) or greater steel sheet, welded.
 - 3. Cover to be constructed of 16ga (1.5 mm) or greater steel sheet, welded.
 - 4. Finish: Chassis and covers to be powder coat painted black. Other components zinc

plated or non-corroding.

5. Gear Reducer: filled with synthetic lubricant allowing operation down to -13° F (-25° C) without a heater.
6. Operator shall contain a position sensing device and a means of setting the limit position and maintaining this position in non-volatile memory. Operator must also contain a magnetic absolute position sensor to verify the gate position.
7. Zinc or nickel plated #40 roller chain with chain mount brackets and connecting hardware.

C. Minimum standard electrical components:

1. Motor: 1/2 hp brushed DC motor with ball bearings.
2. Electronic circuit boards to be conformal coated to resist moisture induced failures.
3. All components shall have overload protection.
4. Controls: Smart DC Controller Board containing:
 - a. inherent entrapment sensor;
 - b. built in audible “warn before operate” system;
 - c. built in timer to close;
 - d. 32 character LCD for reporting of functions and codes with 5 button user interface;
 - e. multiple programmable output relay options;
 - f. anti-tailgate mode;
 - g. built-in power surge/lightning strike protection;
 - h. multi-stage intelligent battery charging under microprocessor control;
 - i. menu configuration, event logging and system diagnostics easily accessible with a PC and HySecurity’s free Smart Touch Analyze and Retrieve Tool;
 - j. RS-232 port for connection to laptop or other computer peripheral and RS-485 connection for network interface;
 - k. dual gate communication connection for bi-parting, sally port, or sequenced gates;
 - l. electromechanical and solid state relays;
 - m. radio option outputs;
 - n. 15 inputs for site specific configurations;
 - o. pulse width modulated control of brushed DC motor using 110A rated solid state switching devices.
5. Transformer: 250 VA, dual voltage. (N/A for solar model)
6. Input power: 115V, 208V/230V Field selectable.
7. Accessory power: 12 VDC, 24 VDC

- D. Required external sensors: See 1.5B. Specify photo eyes or gate edges or a combination thereof to be installed such that the gate will reverse in either direction upon sensing an obstruction.
 - 1. Through Beam or Reflective type photo eyes.
 - 2. Gate edge.
 - 1) Along entire length of gate posts/guide posts/fence posts.
- E. Control devices:
 - 1) Card reader, mounted on pedestal
 - 2) Hy5B plug in type vehicle detectors for free egress loops
 - a) Loop wire: 16 or 18-gauge, XLPE or XHHW-2 which is rated for both wet and dry environments
 - 3) Hy5B plug in type vehicle detectors for vehicle obstruction loops
 - a) Loop wire: 16 or 18-gauge, XLPE or XHHW-2 which is rated for both wet and dry environments
 - 4) Emergency vehicle open devices as dictated by local code.
 - a) Knox fire box
- F. Stop switch, accessible from outside.
- G. Back Drivable: During AC and DC power loss, the gate can be pushed open.

2.3. FACTORY TESTING

- A. Fully assemble and test, at the factory, each gate operator to assure smooth operation, sequencing and electrical connection integrity.
- B. Check all mechanical connections for tightness and alignment. Check all welds for completeness and continuity.
- C. Inspect finishes for completeness. Touch up imperfections prior to shipment.
- D. Check all electrical wires to assure that chafing cannot occur during shipping or operation.

PART 3 – EXECUTION

3.1. SITE EXAMINATION

- A. Locate concrete mounting pad or galvanized steel mounting posts in accordance with approved shop drawings and in compliance with local building codes.

- B. Make sure that gate is operating smoothly under manual conditions before installation of gate operators. Do not proceed until gate panel is aligned and operates without binding.

3.2. INSTALLATION

- A. Install gate operator in accordance with the safety regulations and the manufacturer's product literature and installation instructions, current at the time of installation. Coordinate locations of operators with contract drawings; other trades and shop drawings.
- B. Installer shall ensure that the electrical service to the operator is at least 15A. Electrical wiring to conform to NEC and manufacturer's installation instructions. SlideSmart DC™ HD25 is 500W.

3.3. FIELD QUALITY CONTROL

- A. Test operator through ten full open and close cycles and adjust for operation without binding, scraping or uneven motion. Test limit switches for proper open and close limit positions.
- B. All anchor bolts shall be fully tightened in the finished installation.
- C. Owner, or owner's representative, shall complete "check list" with installing contractor prior to final acceptance of the installation and submit completed warranty documentation to manufacturer.

3.4. CONTINUED SERVICE AND DOCUMENTATION

- A. Train owner's personnel on how to safely shut off electrical power, release and manually operate the gate. Additionally, demonstrate the general maintenance of the gate operator and accessories and provide one copy of "Programming and Operations Manual" for the owner's use. Manuals will identify parts of the equipment for future procurement. Direct maintenance personnel to the technical support sections on HySecurity's website at www.hysecurity.com.

END OF SECTION 323100

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.
- 2. Swing gates.

- B. Related Requirements:

- 1. Section 033000 "Cast-in-Place Concrete" for cast-in-place concrete equipment bases/pads for gate operators and controls and post footings.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

- 1. Inspect and discuss electrical roughing-in, equipment bases, and other preparatory work specified elsewhere.
- 2. Review sequence of operation for each type of gate operator.
- 3. Review coordination of interlocked equipment specified in this Section and elsewhere.
- 4. Review required testing, inspecting, and certifying procedures.

1.4 ACTION SUBMITTALS

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

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:
 - a. Fence and gate posts, rails, and fittings.
 - b. Chain-link fabric, reinforcements, and attachments.
 - c. Gates and hardware.

- B. Shop Drawings: For each type of fence and gate assembly.

- 1. Include plans, elevations, sections, details, and attachments to other work.
- 2. Include accessories, hardware, gate operation, and operational clearances.

- C. Samples for Initial Selection: For each type of factory-applied finish.
- D. Samples for Verification: For each type of component with factory-applied finish, prepared on Samples of size indicated below:
 - 1. Polymer-Coated Components: In 6-inch lengths for components and on full-sized units for accessories.
- E. Delegated-Design Submittal: For structural performance of chain-link fence and gate frameworks, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For professional engineer and factory-authorized service representative.
- B. Product Certificates: For each type of chain-link fence, and gate.
- C. Product Test Reports: For framework strength according to ASTM F1043, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Field quality-control reports.
- E. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gate operators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: For testing fence grounding; member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

1.8 FIELD 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.

1.9 WARRANTY

- A. Special Warranty: 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. Failure to comply with performance requirements.
 - b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 - 2. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design chain-link fence and gate frameworks.
- B. Structural Performance: Chain-link fence and gate frameworks shall withstand the design wind loads and stresses for fence height(s) and under exposure conditions indicated according to ASCE/SEI 7.
 - 1. Design Wind Load: As indicated on Drawings.
 - a. Minimum Post Size: Determine according to ASTM F1043 for post spacing not to exceed 10 feet for Material Group IA, ASTM F1043, Schedule 40 steel pipe.
 - b. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified.
- C. Lightning Protection System: Maximum resistance-to-ground value of 25 ohms at each grounding location along fence under normal dry conditions.

2.2 CHAIN-LINK FENCE FABRIC

- A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist according to "CLFMI Product Manual" and requirements indicated below:
 - 1. Fabric Height: As indicated on Drawings.
 - 2. Steel Wire for Fabric: Wire diameter of 0.148 inch.
 - a. Mesh Size: 2 inches.
 - b. Polymer-Coated Fabric: ASTM F668, Class 2b over zinc-coated steel wire.
 - 1) Color: Black, according to ASTM F934.

- c. Coat selvage ends of metallic-coated fabric before the weaving process with manufacturer's standard clear protective coating.
- 3. Selvage: Knuckled at both selvages.

2.3 FENCE FRAMEWORK

- A. Posts and Rails: ASTM F1043 for framework, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F1043 or ASTM F1083 based on the following:
 - 1. Fence Height: As indicated on Drawings.
 - 2. Light-Industrial-Strength Material: Group IC-L, round steel pipe, electric-resistance-welded pipe.
 - a. Line Post: 2.375 inches in diameter.
 - b. End, Corner, and Pull Posts: 2.375 inches.
 - 3. Horizontal Framework Members: Intermediate, top and bottom rails according to ASTM F1043.
 - a. Top Rail: 1.66 inches in diameter.
 - 4. Brace Rails: ASTM F1043.
 - 5. Metallic Coating for Steel Framework:
 - a. Type A: Not less than minimum 2.0-oz./sq. ft. average zinc coating according to ASTM A123/A123M or 4.0-oz./sq. ft. zinc coating according to ASTM A653/A653M.
 - b. Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
 - c. External, Type B: Zinc with organic overcoat, consisting of a minimum of 0.9 oz./sq. ft. of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than 0.3-mil-thick, zinc-pigmented coating.
 - d. Type C: Zn-5-Al-MM alloy, consisting of not less than 1.8-oz./sq. ft. coating.
 - e. Coatings: Any coating above.
 - 6. Polymer coating over metallic coating.
 - a. Color: Match chain-link fabric, according to ASTM F934.

2.4 TENSION WIRE

- A. Polymer-Coated Steel Wire: 0.177-inch- diameter, tension wire according to ASTM F1664, Class 2b over zinc-coated steel wire.
 - 1. Color: Match chain-link fabric, according to ASTM F934.

2.5 SWING GATES

- A. General: ASTM F900 for gate posts and single swing gate types.
 - 1. Gate Leaf Width: 36 inches.
 - 2. Framework Member Sizes and Strength: Based on gate fabric height as indicated.
- B. Pipe and Tubing:
 - 1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework
 - 2. Gate Posts: Round tubular steel.
 - 3. Gate Frames and Bracing: Round tubular steel.
- C. Frame Corner Construction: Welded or assembled with corner fittings.
- D. Hardware:
 - 1. Hinges: 360-degree inward and outward swing.
 - 2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
 - 3. Lock: Manufacturer's standard internal device.
 - 4. Closer: Manufacturer's standard

2.6 FITTINGS

- A. Provide fittings according to ASTM F626.
- B. Post Caps: Provide for each post.
 - 1. Provide line post caps with loop to receive tension wire or top rail.
- 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 long.
 - 2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails to posts.
- E. Tension and Brace Bands: Pressed steel.
- F. Tension Bars: Steel, length not less than 2 inches 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 rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: According to ASTM F626.

1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, according to the following:

- a. Hot-Dip Galvanized Steel: galvanized coating thickness matching coating thickness of chain-link fence fabric.

I. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz./sq. ft. of zinc.

- a. Polymer coating over metallic coating.

2.7 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M. Provide grout, recommended in writing by manufacturer, for exterior applications.
- B. Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating, and that is recommended in writing by manufacturer for exterior applications.

2.8 GROUNDING MATERIALS

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connectors and Grounding Rods: Listed and labeled for complying with UL 467.
 1. Connectors for Below-Grade Use: Exothermic welded type.
 2. Grounding Rods: Copper-clad steel, 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a certified 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 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 CHAIN-LINK FENCE INSTALLATION

- A. Install chain-link fencing according to ASTM F567 and more stringent requirements specified.
 - 1. Install fencing on established boundary lines inside property line.
- B. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- C. 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. Concealed Concrete: Place top of concrete 2 inches below grade to allow covering with surface material.
 - b. Posts Set into Sleeves in Concrete: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts are inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
 - c. Posts Set into Holes in Concrete: Form or core drill holes not less than 5 inches deep and 3/4 inch larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed according to anchoring material manufacturer's written instructions. Finish anchorage joint to slope away from post to drain water.
- D. Terminal Posts: Install terminal end, corner, and gate posts according to ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 30 degrees or more. For runs exceeding 500 feet, space pull posts an equal distance between corner or end posts.
- E. Line Posts: Space line posts uniformly at 10 feet o.c.
- F. Post Bracing and Intermediate Rails: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. 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 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.

- G. Tension Wire: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch-diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
 - 1. Extended along top and bottom of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.
- H. Top Rail: Install according to ASTM F567, maintaining plumb position and alignment of fence posts. 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.
- I. Intermediate and Bottom Rails: Secure to posts with fittings.
- J. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 1-inch bottom clearance between finish grade or surface 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.
- K. 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 o.c.
- L. 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 according to ASTM F626. Bend ends of wire to minimize hazard to individuals and clothing.
 - 1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 24 inches o.c.
- M. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side.

3.4 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.

3.5 GROUNDING AND BONDING

- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Fence and Gate Grounding:

1. Ground for fence and fence posts shall be a separate system from ground for gate and gate posts.
 2. Install ground rods and connections at maximum intervals of 1500 feet.
 3. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
 4. Ground fence on each side of gates and other fence openings.
 - a. Bond metal gates to gate posts.
 - b. Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.
- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a ground rod located a maximum distance of 150 feet on each side of crossing.
- D. Fences Enclosing Electrical Power Distribution Equipment: Ground according to IEEE C2 unless otherwise indicated.
- E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
1. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
 2. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
- F. Connections:
1. Make connections with clean, bare metal at points of contact.
 2. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 3. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 4. Make above-grade ground connections with mechanical fasteners.
 5. Make below-grade ground connections with exothermic welds.
 6. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- G. Bonding to Lightning Protection System: Ground fence and bond fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor according to NFPA 780.
- H. Comply with requirements in Section 264113 "Lightning Protection for Structures."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests.

- B. Grounding Tests: Comply with requirements in Section 264113 "Lightning Protection for Structures."
- C. Prepare test reports.

3.7 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.
 - 1. Lubricate operator and related components.
- B. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 323113

SECTION 323119 - DECORATIVE METAL 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. Decorative steel fences.
 - 2. Swing gates.
 - 3. Horizontal-slide gates.
- B. Related Requirements:
 - 1. Division 26 Sections for electrical service and connections for system disconnect switches and powered devices including, but not limited to, motor operators, controls, and limit switches.
 - 2. Section 323100 "Gate Operators" for gate operators for decorative metal fences.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For fencing and gates.
 - 1. Include plans, elevations, sections, gate locations, post spacing, and mounting attachment details, and grounding details.
 - 2. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
 - 3. Wiring Diagrams: Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Product Test Reports: For decorative metallic-coated-steel tubular picket fences, including finish, indicating compliance with referenced standard and other specified requirements.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For gate operators to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Fabricator of products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Wind Loading:
 - 1. Fence Height: As indicated on drawings.
 - 2. Wind Exposure Category: As indicated on drawings.
 - 3. Design Wind Speed: As indicated on drawings.
 - 4. Design Wind Pressure: As indicated on drawings.
- B. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

2.2 DECORATIVE STEEL FENCES

- A. Decorative Steel Fences: Fences made from steel tubing bars and shapes, hot-dip galvanized.
 - 1. Manufacturer
 - a. Basis of Design: Ameristar Perimeter Security USA, Inc.
 - 1) Product: Montage II – Heavy Industrial Steel Ornamental Fence System
 - a) Style: Classic
 - b) Color: Black
 - b. Or Approved Equal
- B. Posts: Square steel tubing.
 - 1. Line Posts: 2-3/4 by 2-3/4 inches with 12-gauge wall thickness.
 - 2. End and Corner Posts: 2-3/4 by 2-3/4 inches with 12-gauge wall thickness.
 - 3. Swing Gate Posts: 3 by 3 inches with 12-gauge wall thickness.
 - 4. Horizontal-Slide Gate Post, Openings up to 12 Feet: 3 by 3 inches with 12-gauge wall thickness.
 - 5. Horizontal-Slide Gate Post, Openings Wider Than 12 Feet: 4 by 4 inches with wall thickness.
 - 6. Guide Posts for Class 1 Horizontal-Slide Gates: 3 by 3 inches with 12 gauge wall thickness; installed adjacent to gate post to permit gate to slide in space between.
- C. Post Caps: Formed from steel sheet and hot-dip galvanized after forming.

D. Rails:

1. Steel Tube Rails: Square steel tubing 2 3/4" x 2 3/4" with 12 gauge wall thickness.

E. Pickets: 1 inch square, 14 gauge steel tubes.

1. Extend pickets beyond top rail as indicated and cap with metal spear point finial.
2. Picket Spacing: 4 inches clear, maximum.
3. Treillage: Provide iron castings of pattern indicated between each pair of pickets.

F. Fasteners: Stainless-steel carriage bolts and tamperproof nuts.

G. Fabrication: Assemble fences into sections by welding pickets to rails.

1. Fabricate sections with clips welded to rails for field fastening to posts.
2. Drill posts and clips for fasteners before finishing to maximum extent possible.

H. Fabrication: Fabricate bar grating infill into sections of size indicated.

1. Fabricate rails with clips welded to rails for field fastening to posts.
2. Drill posts, clips, and bar grating for fasteners before finishing to maximum extent possible.

I. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay.

J. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

1. Hot-dip galvanize posts and rails.
2. Hot-dip galvanize rail and picket assemblies after fabrication.
3. Hot-dip galvanize bar grating infill after fabrication.
4. Hot-dip galvanize custom-design rail and infill assemblies after fabrication.

K. Finish for Bar Grating Infill: Powder coating.

L. Finish for Metallic-Coated-Steel Items: High-performance coating.

2.3 SWING GATES

A. Gate Configuration: As indicated.

B. Gate Frame Height: As indicated.

C. Gate Opening Width: 36 inches.

D. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes 2-3/4 by 2-3/4 inches formed from 0.108-inch nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch nominal-thickness steel sheet and hot-dip galvanized after fabrication.

- E. Frame Corner Construction: Welded or assembled with corner fittings.
- F. Additional Rails: Provide as indicated, complying with requirements for fence rails.
- G. Infill: Comply with requirements for adjacent fence.
- H. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.
 - 1. Treillage: Provide iron castings of pattern indicated between each pair of pickets. Finish as specified for adjacent fence.
- I. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than 5 feet wide. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate.
- J. Spring Hinges: BHMA A156.17, Grade 1, suitable for exterior use.
 - 1. Function: 320 - Gate spring pivot hinge. Adjustable tension.
 - 2. Material: Malleable iron; galvanized.
- K. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.
 - 1. Function: 39 - Full surface, triple weight, antifriction bearing.
 - 2. Material: Wrought steel, forged steel, cast steel, or malleable iron; galvanized.
- L. Rim Locks: BHMA A156.5, Grade 1, suitable for exterior use.
 - 1. Material: Cast, forged, or extruded brass or bronze.
 - 2. Mounting Plate: Configuration necessary for mounting locks. Fabricate from 1/8-inch-thick, steel plate; galvanized.
- M. Electric Strikes: BHMA A156.31, Grade 1, of configuration required for use with lock specified, fail-secure, and suitable for exterior use.
 - 1. Mounting Plate: Configuration necessary for mounting electric strikes. Fabricate from 1/8-inch-thick, steel plate; galvanized.
 - 2. Mounting: Mortise into post.
- N. Exit Hardware: BHMA A156.3, Grade 1, Type 1 (rim exit device), with push pad actuating bar, suitable for exterior use.
 - 1. Function: 01 - Exit only, no trim or blank escutcheon 08 - Entrance by lever. Key locks or unlocks lever.
 - 2. Mounting Channel: Bent-plate channel formed from 1/8-inch-thick, steel plate. Channel spans gate frame. Exit device is mounted on channel web, recessed between flanges, with flanges extending 1/8 inch beyond push pad surface.
- O. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay.
- P. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

- Q. Metallic-Coated-Steel Finish: High-performance coating.

2.4 HORIZONTAL-SLIDE GATES

- A. Manufacturer
1. Basis of Design: Ameristar Perimeter Security USA, Inc.
 - a. Product: TransPort II Cantilever Gate
 - 1) Style: Classic
 - 2) Color: Black
 2. Or Approved Equal
- B. Gate Configuration: As indicated.
1. Type: Cantilever slide, with internal roller assemblies.
- C. Gate Frame Height: As indicated.
- D. Gate Opening Width: As indicated.
- E. Automated vehicular gates shall comply with ASTM F2200, Class II.
- F. Galvanized-Steel Frames and Bracing: Fabricate members from square tubing.
1. Frame Members: Square tubes 2-3/4 by 2-3/4 inches formed from 0.108-inch nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch nominal-thickness steel sheet and hot-dip galvanized after fabrication.
 2. Bracing Members: Square tubes 1-3/4 by 1-3/4 inches formed from 0.108-inch nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch nominal-thickness steel sheet and hot-dip galvanized after fabrication.
- G. Frame Corner Construction:
1. Welded frame with panels assembled with bolted or riveted corner fittings and 5/16-inch-diameter, adjustable truss rods for panels 5 feet wide or wider.
 2. Overhead Slide Gates: Welded or assembled with corner fittings including 5/16-inch-diameter, adjustable truss rods for panels 5 feet wide or wider.
- H. Additional Rails: Provide as indicated, complying with requirements for fence rails.
- I. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.
1. Treillage: Provide iron castings of pattern indicated between each pair of pickets. Finish as specified for adjacent fence.
- J. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay.
- K. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A123/A123M. For hardware items, hot-dip galvanize to comply with ASTM A153/A153M.

- L. Metallic-Coated-Steel Finish: High-performance coating.

2.5 STEEL AND IRON

- A. Plates, Shapes, and Bars: ASTM A36/A36M.
- B. Bars (Pickets): Hot-rolled, carbon steel complying with ASTM A29/A29M, Grade 1010.
- C. Tubing: ASTM A500/A500M, cold-formed steel tubing.
- D. Bar Grating: NAAMM MBG 531.
 - 1. Bars: Hot-rolled steel strip, ASTM A1011/A1011M, Commercial Steel, Type B.
 - 2. Wire Rods: ASTM A510/A510M.
- E. Galvanized-Steel Sheet: ASTM A653/A653M, structural quality, Grade 50, with [G90] [G60] coating.
- F. Castings: Either gray or malleable iron unless otherwise indicated.
 - 1. Gray Iron: ASTM A48/A48M, Class 30.
 - 2. Malleable Iron: ASTM A47/A47M.

2.6 COATING MATERIALS

- A. Epoxy Primer for Galvanized Steel: Epoxy primer recommended in writing by topcoat manufacturer.
- B. Phosphate Coating for intermediate Coat
- C. Acrylic coating for Topcoat

2.7 MISCELLANEOUS MATERIALS

- A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
 - 1. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for strength and compatibility in fabricated items.
- B. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi, 3-inch slump, and 1-inch maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C387/C387M mixed with potable water according to manufacturer's written instructions.
- C. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M and specifically recommended by manufacturer for exterior applications.

2.8 GROUNDING MATERIALS

- A. Comply with requirements of Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Grounding Conductors: Size as indicated on Drawings. Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
 - 1. Material above Finished Grade: Copper.
 - 2. Material on or below Finished Grade: Copper.
 - 3. Bonding Jumpers: Braided copper tape, 1-5/8 inch wide and 1/16 inch thick, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
- C. Grounding Connectors and Grounding Rods: Comply with UL 467.
 - 1. Connectors for Below-Grade Use: Exothermic-welded type.
 - 2. Grounding Rods: Copper-clad steel.
 - a. Size: 5/8 by 96 inches.

2.9 METALLIC-COATED-STEEL FINISHES

- A. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A780/A780M.
- B. Surface Preparation: Clean surfaces of oil and other contaminants. Use cleaning methods that do not leave residue. After cleaning, apply a zinc-phosphate conversion coating compatible with the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and apply galvanizing repair paint, complying with SSPC-Paint 20, to comply with ASTM A780/A780M.
- C. High-Performance Coating: Apply epoxy primer, polyurethane intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
 - 1. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.
- B. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

- C. 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 or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

- 1. Construction layout and field engineering are specified in Section 017300 "Execution."

3.3 DECORATIVE FENCE INSTALLATION

- A. Install fences according to manufacturer's written instructions.
- B. Install fences by setting posts as indicated and fastening rails and infill panels to posts. Peen threads of bolts after assembly to prevent removal.
- C. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than 24 inches plus 3 inches for each foot or fraction of a foot that fence height exceeds 4 feet.
- D. 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 and sleeves and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Concealed Concrete: Top 2 inches below grade to allow covering with surface material. Slope top surface of concrete to drain water away from post.
 - 3. Posts Set in Concrete: Extend post to within 6 inches of specified excavation depth, but not closer than 3 inches to bottom of concrete.
 - 4. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least 3/4 inch larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.
 - a. Extend posts at least 5 inches into sleeve.
 - b. After posts have been inserted in sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.
 - 5. Posts Set into Voids in Concrete: Form or core drill holes not less than 3/4 inch larger than outside diagonal dimension of post.
 - a. Extend posts at least 5 inches into concrete.
 - b. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink grout, mixed and placed to comply with grout

manufacturer's written instructions. Finish and slope top surface of grout to drain water away from post.

6. Space posts uniformly at 8 feet o.c.

3.4 GATE INSTALLATION

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. 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.

3.5 GROUNDING AND BONDING

- A. Comply with Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Fence Grounding: Install at maximum intervals of except as follows:
 1. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
 - a. Gates and Other Fence Openings: Ground fence on each side of opening.
 - 1) Bond metal gates to gate posts.
 - 2) Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.
- C. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.
- D. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
- E. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
- F. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
- G. 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.
- H. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
 1. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
 2. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify Architect promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
 3. Report: Prepare test reports of grounding resistance at each test location certified by a testing agency. Include observations of weather and other phenomena that may affect test results.

3.7 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.

3.8 DEMONSTRATION

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

END OF SECTION 323119

SECTION 323223 - SEGMENTAL RETAINING WALLS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Segmental retaining walls.

B. Related Requirements:

1. Section 312000 "Earth Moving" for excavation for segmental retaining walls, base material, soil fill, fill placement and compaction, and field in-place density testing.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at during OAC meeting.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Show sizes, profiles, coursing, and locations of retaining wall units; including backfill and leveling base materials.
2. Show types, sizes, locations of soil reinforcing materials.
3. Global Stability Analysis prepared by a qualified professional engineer.
4. Signed and sealed by the qualified professional engineer responsible for their preparation.

- C. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors and textures for segmental retaining wall units.

- D. Samples for Verification: Actual sample of finished products for each type of exposed finish of segmental retaining wall units.

1. Size: Manufacturers' standard size.

- E. Delegated Design Submittals: For segmental retaining walls, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Product Certificates: For each type of segmental retaining wall unit and soil reinforcement from manufacturer.
 - 1. Include test data for shear strength between segmental retaining wall units in accordance with ASTM D6916.
 - 2. Include test data for connection strength between segmental retaining wall units and soil reinforcement in accordance with ASTM D6638.
- C. Test and Evaluation Reports:
 - 1. Product Test Reports: For each type of segmental retaining wall unit and soil reinforcement, for tests performed by qualified testing agency.
 - a. Include test data for shear strength between segmental retaining wall units in accordance with ASTM D6916.
 - b. Include test data for connection strength between segmental retaining wall units and soil reinforcement in accordance with ASTM D6638.
- D. Source Quality-Control Submittals:
 - 1. Source quality-control reports.
- E. Field Quality-Control Submittals:
 - 1. Field quality-control reports.
- F. Delegated design engineer qualifications.

1.5 QUALITY ASSURANCE

- A. Qualifications:
 - 1. Delegated Design Engineer: A professional engineer who is legally qualified to practice in state where Project is located and who is experienced in providing engineering services of the type indicated.
 - 2. Testing Agency: Qualified in accordance with ASTM E329 for testing indicated.

1.6 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
 - 1. Test soil reinforcement and backfill materials for pullout resistance in accordance with ASTM D6706.
 - 2. Test soil reinforcement and backfill materials for coefficient of friction in accordance with ASTM D5321/D5321M.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.
- B. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F or below 32 deg F, and other conditions that might damage them. Verify identification of geosynthetics before use, and examine them for defects as material is placed.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, licensed in the state where the project is located to design segmental retaining walls.
- B. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.
- C. Structural Performance: Engineering design shall be based on the following loads and be in accordance with NCMA's "Design Manual for Segmental Retaining Walls."
 - 1. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
 - 2. Superimposed loads (surcharge) indicated on Drawings.

2.2 SEGMENTAL RETAINING WALL UNITS

- A. Product: Versa-Lok Four Unit Mosaic Panel
- B. Color: As selected by Architect from manufacturer's full range available.
- C. Batter: Per Manufacturer.
- D. Cap Units: Provide cap units with smooth, as-cast top surfaces without holes or lugs.
- E. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching wall face.

2.3 INSTALLATION MATERIALS

- A. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.

- B. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
- C. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.
- D. Leveling Base: Comply with requirements in Section 312000 "Earth Moving" for base course.
 - 1. Leveling Course: Lean concrete with a compressive strength per qualified wall designer's recommendation.
- E. Drainage Fill: Comply with requirements in Section 312000 "Earth Moving" for drainage course.
- F. Reinforced Soil Fill:
 - 1. Comply with requirements in Section 312000 "Earth Moving" for satisfactory soils.
- G. Nonreinforced-Soil Fill: Comply with requirements in Section 312000 "Earth Moving" for satisfactory soils.
- H. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.
- I. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation of greater than 50 percent.
 - 1. Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D4751.
 - 2. Minimum Grab Tensile Strength: 110 lb; ASTM D4632/D4632M.
 - 3. Minimum Weight: 4 oz./sq. yd..

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect each roll of soil reinforcement for minimum average roll values for geosynthetic index property tests, including the following:
 - 1. Weight.
 - 2. Grab or single-rib strength.
 - 3. Aperture opening.
 - 4. Rib or yarn size.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements

for excavation tolerances, condition of subgrades, and other conditions affecting performance of the Work.

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

3.2 INSTALLATION OF RETAINING WALLS

- A. General: Place units in accordance with NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
 - 1. Lay units per manufacturer's pattern instructions
- B. Do not use units with chips, cracks, or other defects that are visible from pedestrian paths where such defects are exposed in the completed Work.
- C. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
 - 1. Leveling Course: Compact and screed concrete to a smooth, level surface.
- D. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
 - 1. Tamp units into leveling base as necessary to bring tops of units into a level plane.
- E. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
 - 1. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
 - 2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
 - 3. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
 - 4. For units with pins, install pins and align units.
 - 5. For units with clips, install clips and align units.
- F. Cap Units: Place cap units and secure with cap adhesive.

3.3 FILL PLACEMENT

- A. General: Comply with requirements in Section 312000 "Earth Moving," with NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
- B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.

- C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.
 - 1. Use only hand-operated compaction equipment within 48 inches of wall or one-half of height above bottom of wall, whichever is greater.
 - 2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight in accordance with ASTM D698 or per qualified wall designer's recommendations, whichever are more stringent.
 - a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 95 percent maximum dry unit weight in accordance with ASTM D698.
 - b. In areas where fill height exceeds 15 feet compact reinforced-soil fill that will be more than 15 feet below finished grade to not less than 98 percent maximum dry unit weight in accordance with ASTM D698.
 - 3. Compact nonreinforced-soil fill to comply with Section 312000 "Earth Moving."
- D. Place drainage geotextile against back of wall, and place layer of drainage fill per qualified wall designer's recommendation.
- E. Place a layer of drainage fill per qualified wall designer's recommendations. Place a layer of drainage geotextile between drainage fill and soil fill.
- F. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated[, sloped not less than 0.5 percent to drain.
- G. Place impervious fill over top edge of drainage fill layer.
- H. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at wall base away from wall. Provide uniform slopes that prevent ponding.
- I. Place soil reinforcement in horizontal joints of retaining wall where indicated and in accordance with soil-reinforcement manufacturer's written instructions. Embed reinforcement per manufacturer's recommendation into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
 - 1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
 - 2. Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.
 - 3. Do not dump fill material directly from trucks onto geosynthetics.

3.4 CONSTRUCTION TOLERANCES

- A. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet, 3 inches maximum.
- B. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet.
- C. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet.
- D. Maximum Gap between Units: 1/8 inch.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Comply with requirements in Section 312000 "Earth Moving" for field quality control.
- C. Tests and Inspections:
 - 1. In each compacted backfill layer, perform at least one field in-place compaction test for each 100 feet or less of segmental retaining wall length.
 - 2. In each compacted backfill layer, perform at least one field in-place compaction test for each 24 inches of fill depth and each 50 feet or less of segmental retaining wall length.
 - 3. Segmental retaining wall system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Remove and replace segmental retaining wall construction of the following descriptions:
 - 1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Architect approves methods and results.
 - 2. Segmental retaining walls that do not match approved Samples
 - 3. Segmental retaining walls that do not comply with other requirements indicated.
- B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 323223

SECTION 328400 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Piping.
2. Manual valves.
3. Automatic control valves.
4. Automatic drain valves.
5. Sprinklers.
6. Controllers.
7. Boxes for automatic control valves.

B. The irrigation system shall be bid as follows:

1. Includes all new sleeves, two-wire controller, rain sensor, two-wire path, master valve, flow sensor, control valves, decoders, main line, lateral lines, drip tubing, and all other necessary components required to irrigate the trees, shrubs, ground covers, and turf as shown in the drawings.

C. The Irrigation Contractor shall furnish all materials, tools, equipment, and labor to install a complete and operable automatically controlled landscape irrigation system, as indicated on the drawings, as specified, and as necessary to complete the contract, included but not limited to these major items:

1. Submittal of the required material data and shop drawings.
2. Pre-installation flow and pressure tests and the submittal of a report of the findings prior to beginning the actual installation work.
3. Utility locates
4. Coordination of the controller power supply and system water supply point of connection, as applicable, with other trades.
5. Irrigation system sleeving as noted on the drawings or as may be required to complete the installation. This includes scheduling coordination with other trades and minor field adjustment that may be required due to actual site conditions.
6. Excavation and backfill of pipe trenches.
7. As-built drawings.

1.2 PERFORMANCE REQUIREMENTS

- A. Irrigation zone control shall be automatic operation with two-wire controller and automatic control valves.
- B. Delegated Design: Design 100 percent coverage irrigation system, using performance requirements and design criteria indicated.

1.3 SUBMITTALS

- A. General: As soon as practical after notice to proceed and before procurement of any products, the Irrigation Contractor shall submit a scaled plan depicting the proposed irrigation layout with a full schedule or legend listing all components and parts to be incorporated into the system. This plan shall be accompanied by a controller timing schedule indicating timed settings for each automatic controller zone. The Irrigation Contractor shall attach to this plan any catalog cut sheets, diagrams, or details as may be required by the Landscape Architect. Approval of products under this provision shall not be construed as authorizing any deviations from these specifications unless attention has been directed in writing to the specific deviation. Products submitted which are not in accordance with these specifications will be rejected and resubmitted.
- B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. Changes: Once the Irrigation Contractor's submittal has been approved by the Landscape Architect if there are any departures from the approved submittal deemed necessary by the Irrigation Contractor, details of such departures and reasons therefore shall be submitted in writing to the Landscape Architect for review and approval prior to installation.
- D. Quality Assurance Submittals:
 - 1. Qualification data: Irrigation Contractor shall have 5 years of experience in irrigation installation on projects of similar scope and scale.
 - 2. Field quality-control test reports shall include written documentation of pressure tests and findings.
- E. Closeout Submittals
 - 1. Operation and maintenance data.
 - 2. As-Built Drawings: After completing construction and prior to receiving final approval by the Owner, provide an as-built drawing of the irrigation system showing the installed locations and types of all irrigation heads, valve boxes, lateral and main piping with sizes, sleeves with sizes, quick couplers, valves, controller and specialties. All as-built zone numbering shall accurately correspond to those on controller. Recommended run times by season and condition shall be included. The irrigation contractor shall complete and submit the as-built drawings within 10 working days after final installation and prior to requesting final inspection and acceptance.

1.4 QUALITY ASSURANCE

- A. The irrigation contractor is solely responsible for quality control of the work.
- B. The irrigation contractor is responsible for obtaining all required permits and pay associated fees unless otherwise noted.

1.5 INSPECTIONS

- A. The Owner and/or Landscape Architect shall inspect all work. The Irrigation Contractor shall flag and obtain Owner approval for all sleeving, system pipe, heads, valves, and other ancillary components prior to installation. If the work is not being performed in a workmanlike manner as specified, not within construction standards, or not operating under OSHA or Owner's safety

policies, the Owner or Landscape Architect shall recommend halting construction. Construction shall be halted until the portion of the specification or standard is corrected.

1.6 WARRANTY

- A. The Irrigation Contractor shall provide a written warranty covering the entire system against defects in installation, workmanship, and equipment for a period of one year from the date of Final Acceptance.
- B. After the system is installed and approved, the Irrigation Contractor shall facilitate a meeting(s) to instruct the Owner's irrigation manager and/or maintenance staff in the complete operation, winterization, and maintenance of the system.
 - 1. The Irrigation Contractor shall provide a maximum of 8 hours of on-site training to the Owner's maintenance staff after Final Acceptance of the project.
- C. The Irrigation Contractor shall provide the Owner with a warranty transfer that shall confer all applicable product and manufacturers warranties and replacement benefits to the Owner upon Final Acceptance.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- B. Hard Copper Tube: ASTM B 88, Type K, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- C. PE Pipe with Controlled ID: ASTM F 771, PE 3408 compound; SDR 11.5 and SDR 15.
 - 1. Insert Fittings for PE Pipe: ASTM D 2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.
- D. PVC Pipe: ASTM D 1785, PVC 1120 compound, Schedule 40.
 - 1. PVC Socket Fittings: ASTM D 2466, Schedule 40.
 - 2. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
 - 3. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.
- E. PVC Pipe, Pressure Rated: ASTM D 2241, PVC 1120 compound, SDR 21 and SDR 26.
 - 1. PVC Socket Fittings: ASTM D 2467, Schedule 80.

2. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.

2.2 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick unless otherwise indicated; 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. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
- F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 AUTOMATIC CONTROL VALVES

- A. Bronze, Automatic Control Valves:
 1. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.
- B. Plastic, Automatic Control Valves:
 1. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.

2.4 SPRINKLERS

- A. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.
- B. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:
 1. Description:
 - a. Body Material: ABS.
 - b. Nozzle: ABS or Brass.
 - c. Retraction Spring: Stainless steel.
 - d. Internal Parts: Corrosion resistant.
 2. Capacities and Characteristics:
 - a. Pop-up Height: 4 inches aboveground to nozzle.
 - b. Arc: Full to part circle.
- C. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:

1. Description:
 - a. Case: ABS.
 - b. Pop-up Height: 4 inches aboveground to nozzle.
 - c. Sprinkler Construction: ABS and other corrosion-resistant metals.
2. Capacities and Characteristics:
 - a. Nozzle: ABS or Brass.
 - b. Arc: Full to part circle.

D. Plastic, Pop-up Spray Sprinklers:

1. Description:
 - a. Body Material: ABS.
 - b. Nozzle: ABS or Brass.
 - c. Retraction Spring: Stainless steel.
 - d. Internal Parts: Corrosion resistant.
 - e. Pattern: Fixed, with flow adjustment.
 - f. Nozzle: ABS or Brass.
 - g. Pop-up Height: 4 inches aboveground to nozzle.
 - h. Arc: Full to part circle.

E. Plastic Shrub Sprinklers:

1. Description:
 - a. Body Material: ABS or other plastic.
 - b. Pattern: Fixed, with flow adjustment.
2. Capacities and Characteristics:
 - a. Configuration: As needed to provide uniform coverage over desired spray area.
 - b. Arc: Full to part circle.
 - c. Mounting Height: 4 inches aboveground to nozzle.

2.5 CONTROLLERS

A. Description:

1. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
2. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
 - a. Body Material: Stainless-steel sheet metal.
 - b. Mounting: Surface type for wall.
3. Control Transformer: 24-V secondary, with primary fuse.
4. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.

- a. Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
 - b. Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
 - c. Surge Protection: Metal-oxide-varistor type on each station and primary power.
- 5. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
 - 6. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
 - a. Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
 - b. Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
 - c. Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.

2.6 BOXES FOR AUTOMATIC CONTROL VALVES

A. Plastic Boxes:

- 1. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
 - a. Size: As required for valves and service.
 - b. Shape: Round.
 - c. Sidewall Material: PE.
 - d. Cover Material: PE.
- 1) Lettering: "VALVE BOX."

- B. Drainage Backfill: Cleaned gravel or crushed stone, graded from 3/4 inch minimum to 3 inches maximum.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."
- B. Install warning tape directly above pressure piping, 12 inches below finished grades, except 6 inches below subgrade under pavement and slabs.
- C. Provide minimum cover over top of underground piping according to the following:
 - 1. Irrigation Main Piping: Minimum depth of 36 inches below finished grade, or not less than 18 inches below average local frost depth, whichever is deeper.
 - 2. Circuit Piping: 12 inches.

3. Sleeves: 12 inches.

3.2 PIPING INSTALLATION

- A. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
- B. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
- C. Install piping free of sags and bends.
- D. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- E. Install fittings for changes in direction and branch connections.
- F. Install unions adjacent to valves and to final connections to other components with NPS 2 (DN 50) or smaller pipe connection.
- G. Install flanges adjacent to valves and to final connections to other components with NPS 2-1/2 (DN 65) or larger pipe connection.
- H. Install underground thermoplastic piping according to ASTM D 2774 and ASTM F 690.
- I. Install expansion loops in control-valve boxes for plastic piping.
- J. Lay piping on solid subbase, uniformly sloped without humps or depressions.
- K. Install ductile-iron piping according to AWWA C600.
- L. Install PVC piping in dry weather when temperature is above 40 deg F. Allow joints to cure at least 24 hours at temperatures above 40 deg F before testing.

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 pipe and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- E. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.
- F. Copper-Tubing Soldered Joints: Apply ASTM B 813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.
- G. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.
- H. PVC 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. 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.
 - 3. PVC Nonpressure Piping: Join according to ASTM D 2855.

3.4 VALVE INSTALLATION

- A. Throttling Valves: Install in underground piping in boxes for automatic control valves.
- B. Drain Valves: Install in underground piping in boxes for automatic control valves.

3.5 SPRINKLER INSTALLATION

- A. Install sprinklers after hydrostatic test is completed.
- B. Install sprinklers at manufacturer's recommended heights.
- C. Locate part-circle sprinklers to maintain a minimum distance of 4 inches from walls and 2 inches from other boundaries unless otherwise indicated.

3.6 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

- A. Install control cable in same trench as irrigation piping and at least 2 inches below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.

3.7 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 220553 "Identification for Plumbing Piping and Equipment."
- B. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.

1. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
- C. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling. See Section 312000 "Earthwork" for warning tapes.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- 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, operate controllers and automatic control valves to confirm proper system operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Any irrigation product will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.9 ADJUSTING

- A. Adjust settings of controllers.
- B. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.
- C. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than 1/2 inch above, finish grade.

END OF SECTION 328400

SECTION 329113 - SOIL PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes all labor, materials, tools, supplies, equipment, facilities, transportation, and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Planting Soil and /or the modification of existing site soil for use as Planting Soil, complete as shown on the drawings and as specified herein.
- B. Related Requirements:
 - 1. Section 329200 "Turf and Grasses" for turf seeding.
 - 2. Section 329300 "Plants" for plants, mulches, and landscape edgings.

1.2 DEFINITIONS

- A. Amendment: material added to Topsoil to produce Planting Soil Mix. Amendments are classified as general soil amendments, fertilizers, biological, and pH amendments.
- B. Biological Amendment: Amendments such as Mycorrhizal additives, compost tea or other products intended to change the soil biology.
- C. Compost: well decomposed stable organic material as defined by the US Composting Council.
- D. Existing Soil: Mineral soil existing at the locations of proposed planting after most of the construction within and around the planting site is completed and just prior to the start of work to prepare the planting area for soil modification and/or planting.
- E. Fertilizer: Amendment used for adjusting soil nutrient composition and balance.
- F. Fine grading: The final grading of the soil to achieve exact contours and positive drainage, often accomplished by hand rakes or drag rakes other suitable devices, and further defined in this specification, and further defined in this specification.
- G. Finished Grade: Surface or elevation of Planting Soil after final grading and 12 months of settlement of the soil.
- H. Imported Soil: Soil that is transported to Project site for use.
- I. Manufactured Soil: Soil produced by blending soils, sand, stabilized organic soil amendments, and other materials to produce planting soil.
- J. Owner's Representative: The person or entity, appointed by the Owner to represent their interest in the review and approval of the work and to serve as the contracting authority with the Contractor. The Owner's Representative may appoint other persons to review and approve any aspects of the work.

- K. Ped: a clump or clod of soil held together by a combination of clay, organic matter, and fungal hyphae, retaining the original structure of the harvested soil.
- L. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified as specified in Part 2 of this section to produce a soil mixture best for plant growth.
- M. Soil Horizons: as defined in the USDA National Soil Survey Handbook

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

- N. 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.
- O. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- P. Topsoil: Naturally produced and harvested soil from the “A” horizon or upper layers of the soil, excluding any duff, decayed leaves, twigs, and organic detritus.
- Q. Undisturbed soil: Soils with the original A horizon intact that have not been graded or compacted. Soils that have been farmed, subjected to fire, or logged but not graded, and natural forested land will be considered as undisturbed.
- R. USCC: U.S. Composting Council.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 SUBMITTALS

- A. Product data and certificates: For each type of manufactured product, submit data and certificates that the product meets the specification requirements, signed by the product manufacturer.
- B. Samples: Submit samples of each product and material, where required by Part 2 of the specification, to the Owner’s Representative for approval. Label samples to indicate product, characteristics, and locations in the work. Samples will be reviewed for appearance only.
 - 1. Submit samples a minimum of 4 weeks prior to the anticipated date of the start of soil installation.
 - 2. Samples of all Planting Soil Mixes shall be submitted at the same time as the soil test results of that material.
- C. Soil testing for Topsoil, Existing Soil, Compost, and Planting Soil Mixes.
 - 1. Submit soil test analysis report for each sample of Topsoil, Existing Soil, Compost and Planting Soil from an approved soil-testing laboratory, as follows:
 - a. Submit Topsoil, Existing Soil, and Compost for testing at least 8 weeks before scheduled installation of Planting Soil Mixes. Submit Planting Soil Mix test no more than 2 weeks after the approval of the Topsoil, Existing Soil, and Compost.

- Do not submit Planting Soil Mixes to the testing laboratory for testing until all Topsoil, Existing Soil, and Compost results have been approved.
- b. If tests fail to meet the specifications, obtain other sources of material, retest and resubmit until accepted by the Owner's Representative.
 - c. All soil testing will be at the expense of the Contractor.
2. For each Topsoil, Existing Soil, and Planting Soil Mix sample, submit the following analyses:
- a. Particle size analysis (% dry weight)
 - b. USDA soil texture
 - c. pH and buffer pH.
 - d. Percent organic content by oven dried weight.
 - e. Nutrient levels by parts per million including: phosphorus, potassium, magnesium, manganese, iron, zinc, and calcium. Nutrient test shall include the testing laboratory recommendations for supplemental additions to the soil for optimum growth of the plantings specified.
 - f. Soluble salt by electrical conductivity of a 1:2 soil water sample measured in Milliohm per cm.
 - g. Cation Exchange Capacity (CEC).
3. For each Compost product, submit the following analyses:
- a. pH
 - b. Salt concentration (electrical conductivity)
 - c. Moisture content %, wet weight basis
 - d. Particle size % passing a selected mesh size, dry weight basis
 - e. Stability carbon dioxide evolution rate mg CO₂-C per g OM per day
 - f. Solvita maturity test
 - g. Physical contaminants (inerts) %, dry weight basis
 - h. US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels Chemical Contaminants mg/kg (ppm)

1.5 OBSERVATION OF THE WORK

- A. The Owner's Representative may observe the work at any time. They may remove samples of materials for conformity to specifications. Rejected materials shall be immediately removed from the site and replaced at the Contractor's expense. The cost of testing materials not meeting specifications shall be paid by the Contractor.
 - 1. The Owner's Representative may utilize the Contractor's penetrometer and moisture meter at any time to check soil compaction and moisture.
- B. The Owner's Representative shall be informed of the progress of the work so the work may be observed at the following key times in the construction process. The Owner's Representative shall be afforded sufficient time to schedule visit to the site. Failure of the Owner's Representative to make field observations shall not relieve the Contractor from meeting all the requirements of this specification.
 - 1. COMPLETION of SOIL MODIFICATIONS REVIEW: Upon completion of all soil modification and installation of planting soil.
 - 2. COMPLETION OF FINE GRADING AND SURFACE SOIL MODIFICATIONS REVIEW: Upon completion of all surface soil modifications and fine grading but prior to the installation of shrubs, ground covers, or lawns.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: The installer shall be a firm having at least 5 years of experience of a scope like that required for the work, including the preparation, mixing and installation of soil mixes to support planting. The installer of the work in Section: Planting, shall be the same firm installing the work in this section.
- B. Soil testing laboratory qualifications: an independent laboratory, with the experience and capability to conduct the testing indicated and that specializes in USDA agricultural soil testing, Planting Soil Mixes, and the types of tests to be performed. Geotechnical engineering testing labs shall not be used.

1.7 SITE CONDITIONS

- A. It is the responsibility of the Contractor to be aware of all surface and subsurface conditions, and to notify the Owner's Representative, in writing, of any circumstances that would negatively impact the health of plantings. Do not proceed with work until unsatisfactory conditions have been corrected.
 - 1. Should subsurface drainage or soil conditions be encountered which would be detrimental to growth or survival of plant material, the Contractor shall notify the Owner's Representative in writing, stating the conditions and submit a proposal covering cost of corrections. If the Contractor fails to notify the Owner's Representative of such conditions, they shall remain responsible for plant material under the warrantee clause of the specifications.
 - 2. This specification requires that all Planting Soil and Irrigation (if applicable) work be completed and accepted prior to the installation of any plants.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Weather: Do not mix, deliver, place or grade soils when frozen or with moisture above field capacity.
- B. Protect soil and soil stockpiles, including the stockpiles at the soil blender's yard, from wind, rain and washing that can erode soil or separate fines and coarse material, and contamination by chemicals, dust and debris that may be detrimental to plants or soil drainage. Cover stockpiles with plastic sheeting or fabric at the end of each workday.
- C. All manufactured packaged products and material shall be delivered to the site in unopened containers and stored in a dry enclosed space suitable for the material and meeting all environmental regulations. Biological additives shall be protected from extreme cold and heat. All products shall be freshly manufactured and dated for the year in which the products are to be used.
- D. Deliver all chemical amendments in original, unopened containers with original labels intact and legible, which state the guaranteed chemical analysis. Store all chemicals in a weather protected enclosure.
- E. Bulk material: Coordinate delivery and storage with Owner's Representative and confine materials to neat piles in areas acceptable to Owner's Representative.

1.9 EXCAVATING AND GRADING AROUND UTILITIES

- A. Contractor shall carefully examine the civil, record, and survey drawings to become familiar with the existing underground conditions before digging.
- B. Determine location of underground utilities and perform work in a manner that will avoid damage. Hand-excavate as required. Maintain grade stakes set by others until parties concerned mutually agree upon removal.
- C. Notification of the *Missouri One Call System* at **811**, is required for all planting areas: The Contractor is responsible for knowing the location and avoiding utilities that are not covered by the *Missouri One Call System*.

PART 2 - PRODUCTS

2.1 PLANTING SOIL MIX

- A. General definition: A mix of Existing Soil, Topsoil, and Compost to make a new soil that meets the project goals for the indicated planting areas. These will be mixed on-site and will consist of the mix components and in the proportions as indicated.
- B. Planting Mix
 - 1. A Mix of Existing Soil, Topsoil, and Compost in the following ratio:

<u>Mix component % by moist volume</u>	
Existing Soil	65-70%
Topsoil (unscreened)	25-30%
Compost	5%
 - 2. Final tested organic matter between 2.75 and 4% (by dry weight).
 - 3. Mix the Topsoil and Compost together first and then add to the Existing Soil. Mix with a loader bucket to loosely incorporate the Topsoil/Compost Mix into the Existing Soil. DO NOT OVER MIX! Do not mix with a soil blending machine. Do not screen the soil. Clumps of Topsoil, Compost and Existing Soil will be permitted in the overall Mix.
 - 4. At the time of final grading, add lime or other inorganic amendments, only if required, at rates recommended by the testing results for the plants to be grown.
 - 5. Provide a two-gallon sample with testing data that includes recommendations for chemical additives for the types of plants to be grown. Samples and testing data shall be submitted at the same time.

2.2 COMPOST

- A. Compost: Blended and ground leaf, wood, and other plant-based material, composted for a minimum of 9 months and at temperatures sufficient to break down all woody fibers, seeds and leaf structures, free of toxic material at levels that are harmful to plants or humans. Source material shall be yard waste trimmings blended with other plant or manure-based material designed to produce Compost high in fungal material.

Compost shall be commercially prepared Compost and meet US Compost Council STA/TMECC criteria or as modified in this section for "Compost as a Landscape Backfill Mix Component". http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/191/LandscapeArch_Specs.pdf

- 1. Compost shall comply with the following parameters:

- a. pH: 5.5 - 8.0.
 - b. Soil salt (electrical conductivity): maximum 5 dS/m (mmhos/cm).
 - c. Moisture content %, wet weight basis: 30 – 60.
 - d. Particle size, dry weight basis: 98% pass through 3/4-inch screen or smear.
 - e. Stability carbon dioxide evolution rate: mg CO₂-C/ g OM/ day < 2.
 - f. Solvita maturity test: > 6.
 - g. Physical contaminants (inerts), %, dry weight basis: <1%.
 - h. Chemical contaminants, mg/kg (ppm): meet or exceed US EPA Class A standard, 40CFR § 503.13, Tables 1 and 3 levels.
 - i. Biological contaminants select pathogens fecal coliform bacteria, or salmonella, meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) level requirements.
- B. Provide a two-gallon sample with manufacturer's literature and material certification that the product meets the requirements.

2.3 LIME

- A. 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 a No. 8 (2.36-mm) sieve and a minimum of 75 percent passing through a No. 60 (0.25-mm) sieve.
 - 2. Form: Provide lime in form of ground dolomitic limestone
- B. Provide manufacturer's literature and material certification that the product meets the requirements.

PART 3 - EXECUTION

3.1 SITE EXAMINATION

- A. Prior to installation of Planting Soil, examine site to confirm that existing conditions are satisfactory for the work of this section to proceed.
- 1. Confirm that the subgrade is at the proper elevation and compacted as required.
 - 2. Confirm that the surface of all areas to be filled with Planting Soil are free of construction debris, refuse, compressible or biodegradable materials, stones greater than 2 inches diameter, soil crusting films of silt or clay that reduces or stops drainage from the Planting Soil into the subsoil; and/or standing water. Remove unsuitable material from the site.
 - 3. Confirm that no adverse drainage conditions are present.
 - 4. Confirm that no conditions are present which are detrimental to plant growth.
 - 5. Confirm that utility work has been completed per the drawings.
 - 6. Confirm that irrigation work, which is shown to be installed below prepared soil levels, has been completed.
- B. If unsatisfactory conditions are encountered, notify the Owner's Representative immediately to determine corrective action before proceeding.

3.2 SITE PREPARATION

- A. Excavate to the proposed subgrade. Maintain all required angles of repose of the adjacent materials as shown on the drawings or as required by this specification. Do not over excavate compacted subgrades of adjacent pavement or structures. Maintain a supporting 1:1 side slope of compacted subgrade material along the edges of all paving and structures where the bottom of the paving or structure is above the bottom elevation of the excavated planting area.
- B. Remove all construction debris and material including any construction materials from the subgrade.
- C. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope approximately parallel to the finished grade and/or toward the subsurface drain lines as shown on the drawings.
- D. In areas where Planting Soil is to be spread, confirm subgrade has been scarified.
- E. Protect adjacent walls, walks and utilities from damage or staining by the soil. Use 1/2-inch plywood and or plastic sheeting as directed to cover existing concrete, metal and masonry work and other items as directed during the progress of the work.
 - 1. At the end of each working day, clean up any soil or dirt spilled on any paved surface.
 - 2. Any damage to the paving or site features or work shall be repaired at the Contractor's expense.

3.3 PLANTING SOIL MIX INSTALLATION

- A. Prior to installing any Planting Soil from stockpiles or Planting Soil Mixes blended off site, the Owner's Representative shall approve the condition of the subgrade and the previously installed subgrade preparation and the installation of subsurface drainage.
- B. All equipment utilized to install, or grade Planting Soils shall be wide track or balloon tire machines rated with a ground pressure of 4 psi or less. All grading and soil delivery equipment shall have buckets equipped with 6-inch-long teeth to scarify any soil that becomes compacted.
- C. In areas of soil installation above existing subsoil, scarify the subgrade material prior to installing Planting Soil.
 - 1. Scarify the subsoil of the subgrade to a depth of 3 – 6 inches with the teeth of the backhoe or loader bucket, tiller, or another suitable device.
 - 2. Immediately install the Planting Soil. Protect the loosened area from traffic. DO NOT allow the loosened subgrade to become compacted.
 - 3. If the loosened area becomes overly compacted, loosen the area again prior to installing the Planting Soil.
- D. Install the Planting Soil in 12 - 18-inch lifts to the required depths. Apply compacting forces to each lift as required to attain the required compaction. Scarify the top of each lift prior to adding more Planting Soil by dragging the teeth of a loader bucket or backhoe across the soil surface to roughen the surface.
- E. Phase work such that equipment to deliver or grade soil does not have to operate over previously installed Planting Soil. Work in rows of lifts the width of the extension of the bucket on the loader. Install all lifts in one row before proceeding to the next. Work out from the furthest part of each bed from the soil delivery point to the edge of each bed area.

- F. Where possible place large trees first and fill Planting Soil around the root ball.
- G. Installing soil with soil or mulch blowers or soil slingers shall not be permitted due to the over mixing and soil ped breakdown cause by this type of equipment.
- H. Where travel over installed soil is unavoidable, limit paths of traffic to reduce the impact of compaction in Planting Soil. Each time equipment passes over the installed soil it shall reverse out of the area along the same path with the teeth of the bucket dropped to scarify the soil. Comply with the paragraph "Compaction Reduction" (Section 3.9) if soil becomes over compacted.
- I. The depths and grades shown on the drawings are the final grades after settlement and shrinkage of the compost material. The Contractor shall install the Planting Soil at a higher level to anticipate this reduction of Planting Soil volume. A minimum settlement of approximately 10 - 15% of the soil depth is expected. All grade increases are assumed to be as measured prior to addition of surface Compost till layer, mulch, or sod.

3.4 COMPACTION REQUIREMENTS

- A. Compact installed Planting Soil to the compaction rates indicated and using the methods approved for the soil mockup. Compact each soil lift as the soil is installed.
- B. Installed Planting Soil Mix and re-spread existing soil shall have a soil density through the required depth of the installed layers of soil, such that the penetrometer reads approximately 75 to 250 psi at soil moisture approximately the mid-point between wilt point and field capacity. This will be approximately between 75 and 82% of maximum dry density standard proctor.
- C. Planting Soil compaction shall be tested at each lift using a penetrometer calibrated to the mockup soil and its moisture level. The same penetrometer and moisture meter used for the testing of the mockup shall be used to test installed soil throughout the work.
- D. Maintain moisture conditions within the Planting Soil during installation or modification to allow for satisfactory compaction. Suspend operations if the Planting Soil becomes wet. Apply water if the soil is overly dry.
- E. Provide adequate equipment to achieve consistent and uniform compaction of the Planting Soils. Use the smallest equipment that can reasonably perform the task of spreading and compaction. Use the same equipment and methods of compaction used to construct the Planting Soil mockup.
- F. Do not pass motorized equipment over previously installed and compacted soil except as authorized below.
 - 1. Light weight equipment such as trenching machines or motorized wheelbarrows is permitted to pass over finished soil work.
 - 2. If work after the installation and compaction of soil compacts the soil to levels greater than the above requirements, follow the requirements of the paragraph "Over Compaction Reduction" below.

3.5 OVER COMPACTION REDUCTION

- A. Any soil that becomes compacted to a density greater than the specified density and/or the density in the approved mockup shall be dug up and reinstalled. This requirement includes compaction caused by other sub-contractors after the Planting Soil is installed and approved.
- B. Surface roto tilling shall not be considered adequate to reduce over compaction at levels 6 inches or greater below finished grade.

3.6 INSTALLATION OF CHEMICAL ADDITIVES

- A. Following the installation of each soil and prior to fine grading and installation of the Compost till layer, apply chemical additives as recommended by the soil test, and appropriate to the soil and specific plants to be installed.
- B. Types, application rates and methods of application shall be approved by the Owner's Representative prior to any applications.

3.7 FINE GRADING

- A. The Owner's Representative shall approve all rough grading prior to the installation of Compost, fine grading, planting, and mulching.
- B. Grade the finish surface of all planted areas to meet the grades shown on the drawings, allowing the finished grades to remain higher (10 – 15% of depth of soil modification) than the grades on the grading plan, as defined in paragraph Planting Soil Installation, to anticipate settlement over the first year.
- C. Utilize hand equipment, small garden tractors with rakes, or small garden tractors with buckets with teeth for fine grading to keep surface rough without further compaction. Do not use the flat bottom of a loader bucket to fine grade, as it will cause the finished grade to become overly smooth and or slightly compressed.
- D. Provide for positive drainage from all areas toward the existing inlets, drainage structures and or the edges of planting beds. Adjust grades as directed to reflect actual constructed field conditions of paving, wall, and inlet elevations. Notify the Owner's Representative if conditions make it impossible to achieve positive drainage.
- E. Provide smooth, rounded transitions between slopes of different gradients and direction. Modify the grade so that the finish grade before adding mulch and after settlement is one or two inches below all paving surfaces or as directed by the drawings.
- F. Fill all dips and remove any bumps in the overall plane of the slope. The tolerance for dips and bumps in shrub and ground cover planting areas shall be a 2-inch deviation from the plane in 10 feet. The tolerance for dips and bumps in lawn areas shall be a 1-inch deviation from the plane in 10 feet.

3.8 INSTALLATION OF COMPOST TILL LAYER

- A. After Planting Soil Mixes are installed in planting bed areas and just prior to the installation of shrub or groundcover plantings, spread 3 inches of Compost over the beds and roto till into the top 6 inches of the Planting Soil. This step will raise grades slightly above the grades required in paragraph “Fine Grading”. This specification anticipates that the raise in grade due to this tilling will settle within a few months after installation as Compost breaks down. Additional settlement as defined in paragraph “Planting Soil and Planting Soil Mix installation” must still be accounted for in the setting of final grades.

3.9 CLEAN-UP

- A. During installation, keep the site free of trash, pavements reasonably clean and work area in an orderly condition at the end of each day. Remove trash and debris in containers from the site no less than once a week.
 - 1. Immediately clean up any spilled or tracked soil, fuel, oil, trash, or debris deposited by the Contractor from all surfaces within the project or on public right of ways and neighboring property.
- B. Once installation is complete, wash all soil from pavements and other structures. Ensure that mulch is confined to planting beds and that all tags and flagging tape are removed from the site. The Owner’s Representative seals are to remain on the trees and removed at the end of the warranty period.
 - 1. Make all repairs to grades, ruts, and damage to the work or other work at the site.
 - 2. Remove and dispose of all excess Planting Soil, subsoil, mulch, plants, packaging, and other material brought to the site by the Contractor.

3.10 PLANTING SOIL AND MODIFIED EXISTING SOIL PROTECTION

- A. The Contractor shall protect installed and/or modified Planting Soil from damage including contamination and over compaction due to other soil installation, planting operations, and operations by other Contractors or trespassers. Maintain protection during installation until acceptance. Utilize fencing and matting as required or directed to protect the finished soil work. Treat, repair, or replace damaged Planting Soil immediately.
- B. Loosen compacted Planting Soil and replace Planting Soil that has become contaminated as determined by the Owner’s Representative. Planting Soil shall be loosened or replaced at no expense to the Owner.
 - 1. Till and restore grades to all soil that has been driven over or compacted during the installation of plants.
 - 2. Where modified existing soil has become contaminated and needs to be replaced, provide imported soil that is of similar composition, depth and density as the soil that was removed.

3.11 PROTECTION DURING CONSTRUCTION

- A. The Contractor shall protect planting and related work and other site work from damage due to planting operations, operations by other Contractors or trespassers.
 - 1. Maintain protection during installation until the date of plant acceptance (see specifications section – Planting). Treat, repair, or replace damaged work immediately.

2. Provide temporary erosion control as needed to stop soil erosion until the site is stabilized with mulch, plantings, or turf.

- B. Damage done by the Contractor, or any of their sub-contractors to existing or installed plants, or any other parts of the work or existing features to remain, including large existing trees, soil, paving, utilities, lighting, irrigation, other finished work, and surfaces including those on adjacent property, shall be cleaned, repaired, or replaced by the Contractor at no expense to the Owner. The Owner's Representative shall determine when such cleaning, replacement or repair is satisfactory. Damage to existing trees shall be assessed by a certified arborist.

3.12 SUBSTANTIAL COMPLETION ACCEPTANCE

- A. Upon written notice from the Contractor, the Owners Representative shall review the work and decide if the work is substantially complete.
- B. The date of substantial completion of the planting soil shall be the date when the Owner's Representative accepts that all work in the Soil Preparation, Planting, and Turf and Grass installation sections is complete.

3.13 FINAL ACCEPTANCE / SOIL SETTLEMENT

- A. At the end of the plant warrantee and maintenance period, (see Specification section - Planting) the Owner's Representative shall observe the soil installation work and establish that all provisions of the contract are complete, and the work is satisfactory.
 1. Restore any soil settlement and or erosion areas to the grades shown on the drawings. When restoring soil grades remove plants and mulch and add soil before restoring the planting. Do not add soil over the root balls of plants or on top of mulch.
- B. Failure to pass acceptance: If the work fails to pass final acceptance, any subsequent observations must be rescheduled as per above. The cost to the Owner for additional observations will be charged to the Contractor at the prevailing hourly rate of the Owner's Representative.

END OF SECTION 329113

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Turf Seeding.
 - 2. Turf Sodding
 - 3. Native Wetland Seed Mix

1.2 DEFINITIONS

- A. 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.
- B. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" for planting soils.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 INFORMATIONAL SUBMITTALS

- A. Certification of turf grass.
 - 1. Certification of each seed mixture for turf grass.
 - 2. Certification of turf grass sod
- B. Product certificates for native wetland seed mix

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful turf and native grass establishment.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.

2. Pesticide Applicator: State licensed, commercial.

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 compliance with state and Federal laws, as applicable.

PART 2 - PRODUCTS

2.1 TURF SEED

- A. Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Rules for Testing Seeds" for purity and germination tolerances.
- B. Species:
 1. Quality: Seed of grass species as listed below, with not less than 85 percent germination, not less than 95 percent pure seed, and not more than 0.5 percent weed seed:
 - a. 85 percent Turf-type tall fescue
 - b. 10 percent Kentucky bluegrass
 - c. 5 percent Annual ryegrass

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 that is strongly rooted and capable of vigorous growth and development when planted.
- B. Turfgrass Species: Sod of grass species as follows:
 1. Turf type tall fescue harvested from a sod farm located within 100 miles of the project site.
- C. Sod shall contain a growth of not more than ten (10%) percent of other grasses and clovers, shall be free from all prohibited and noxious weeds and shall be 3/4" to 1-1/4" thick. Sod shall be cut in strips not less than 18" wide and 3' long.

2.3 NATIVE WETLAND SEED MIX

- A. Mix of sedges, rushes, wildflowers and grasses that withstand saturated soils. Includes a minimum of twenty (20) species that are adapted to the Midwest climate.
- B. Proprietary mixtures: Subject to compliance with requirements, provide the following mixture, or an approved equal:
 1. All-Star FACW Wetland Mix by Star Seed, Inc., 101 Industrial Avenue, Osborne, Kansas 67473. Phone: (800) 782-7311. Fax: (785) 346-2479. Website: <https://www.gostarseed.com>

C.

2.4 FERTILIZERS

- A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 1 lb./1,000 sq. ft. of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.

2.5 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.

2.6 PESTICIDES

- A. General: Pesticide, registered and approved by the 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.

PART 3 - EXECUTION

3.1 SEED AREA PREPARATION

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- C. Before planting, obtain Landscape Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.2 NATIVE WETLAND SEEDING

- A. Broadcast seed onto a firm but moist seedbed. Roll lightly and water with fine spray.
- B. Broadcast seed by using an agitating spreader (such as a Vicon Seeder) mounted to a tractor or ATV between the dates of November 1 and February 28 or April 1 and June 15. Do not broadcast or drop seed when wind velocity exceeds 5 mph.
 - 1. Evenly distribute seed mixture by sowing equal quantities in two directions at right angles to each other.

2. Mix seed with a weed-free carrier of either moist sand or sawdust in a 4:1 proportion to the seed.
- C. Sow seed at a total rate of not less than 20 PLS pounds per acre.
- D. After sowing, incorporate the seeds into the soil with a light drag, such as a piece of chainlink fence pulled behind the tractor or ATV.
- E. Protect seeded areas by spreading weed-free straw mulch. Spread uniformly at a minimum rate of 1 to 1-1/2 bales per 1,000 sq. ft. to form a continuous blanket 1 inch in depth.

3.3 NATIVE WETLAND MAINTENANCE

- A. General: Maintain and establish native vegetation in first year by watering, string trimming, selective weeding, and performing other operations as required to establish healthy, viable native wetland vegetation. Roll, regrade, and replant bare or eroded areas and remulch to produce uniform coverage. Provide materials and installation the same as those used in the original installation.
- B. Control weeds by monitoring monthly during the first growing season and employing a flail mower, string trimmer, and/or a selective pre-emergent herbicide. Do not manually weed. Do not mow. Do not apply a general broadleaf herbicide.

3.4 TURF SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph.
 1. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 2. Do not use wet seed or seed that is moldy or otherwise damaged.
 3. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 8 to 10 lbs./1,000 sq. ft.
- C. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 1 to 1-1/2 bales/1,000 sq. ft. to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas.

3.5 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 soil or sod during installation. Tamp and roll lightly to ensure contact with soil, 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 slopes exceeding 1:3.
 2. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than two anchors per sod strip to prevent slippage.
- C. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of 1-1/2 inches below sod.

3.6 TURF MAINTENANCE

- A. General: 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 remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
- B. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than one-third of grass height. Remove no more than one-third of grass-leaf growth in initial or subsequent mowings.

3.7 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by the Landscape 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. and bare spots not exceeding 5 by 5 inches.
- B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants.
2. Mulches
3. Landscape edgings.

1.2 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. Pesticides include insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. They also include substances or mixtures intended for use as a plant regulator, defoliant, or desiccant. Some sources classify herbicides separately from pesticides.
- C. Planting Soil: Existing, on-site soil; imported soil; or manufactured soil that has been modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth. See Section 329113 "Soil Preparation" for drawing designations for planting soils.
- D. 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.

1.3 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Samples of each type of mulch.

1.5 INFORMATIONAL SUBMITTALS

- A. Product certificates.
- B. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: Recommended procedures to be established by Owner for maintenance of plants during a calendar year.

1.7 QUALITY ASSURANCE

- A. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. 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.
- B. Handle planting stock by root ball.
- C. 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.

1.9 WARRANTY

- A. Special Warranty: 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.
 - b. Structural failures including plantings falling or blowing over.
 - 2. Warranty Periods: From date of Substantial Completion.
 - a. Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
 - b. Ground Covers, Biennials, Perennials, and Other Plants: 12 months.

PART 2 - PRODUCTS

2.1 PLANT MATERIAL

- A. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant List, Plant Schedule, or Plant Legend indicated 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.
- B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which begins at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- C. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery.

2.2 FERTILIZERS

- A. 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: 5-gram tablets.
 - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.3 MULCHES

- A. Organic Mulch: Shredded hardwood bark ONLY in tree rings surrounded by lawn.
- B. Decorative Rock Mulch: Missouri Rainbow from House of Rocks (913-432-5990) or approved equal.
 - 1. Size Range: 3 inches maximum, 1 inch minimum.
 - 2. Color: Readily available natural river rock color range.

2.4 WEED-CONTROL BARRIERS

- A. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally encountered chemicals, alkalis, and acids.

2.5 PRE-EMERGENT TREATMENT

- A. General: Pesticide registered and approved by the 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.

2.6 LANDSCAPE EDGINGS

- A. Steel Edging: Standard commercial-steel edging, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
 - 1. Border King Steel Landscape Edging by Border Concepts, Inc., or approved equal.
 - 2. Edging Size: ¼-inch thick by 5 inches deep.
 - 3. Finish: Black.

PART 3 - EXECUTION

3.1 PLANTING AREA ESTABLISHMENT

- A. General: Prepare planting area for soil placement and mix planting soil according to Section 329113 "Soil Preparation."
- B. Placing Planting Soil: Place and mix planting soil in-place over exposed subgrade.
- C. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.

3.2 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits.
 - 1. Excavate planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are unacceptable. 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.
 - 2. Excavate approximately two times as wide as ball diameter.
 - 3. Excavate at least double the width of the root ball and deep enough to accommodate vertical roots for bare-root stock.
 - 4. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
- B. Backfill Soil: Subsoil and topsoil removed from excavations may be used as backfill soil unless otherwise indicated.

3.3 TREE, SHRUB, AND VINE PLANTING

- A. Inspection: At time of planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.
- B. Roots: Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Set each plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
 - 1. Backfill: Planting soil.
 - 2. Balled and Burlapped Stock: 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. Container-Grown Stock: Carefully remove root ball from container without damaging root ball or plant.
 - 4. Fabric Bag-Grown Stock: Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 - 5. Bare-Root Stock: Support stem of each plant and spread roots without tangling or turning toward surface. Plumb before backfilling and maintain plumb while working. Carefully work backfill around roots by hand. Bring roots into close contact with the soil.
 - 6. 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.
 - 7. Place planting tablets equally distributed around each planting pit when pit is approximately one-half filled. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
 - a. Bare-Root Stock: Place tablets beside soil-covered roots; do not place tablets touching the roots.
 - b. Quantity: Two per plant.
 - 8. Continue backfilling process. Water again after placing and tamping final layer of soil.
- D. Slopes: 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.

3.4 TREE, SHRUB, AND VINE PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
- C. 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.

- D. Do not apply pruning paint to wounds.

3.5 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants other than trees, shrubs, and vines as indicated on Drawings in even rows with triangular spacing.
- B. Use planting soil for backfill.
- C. Dig holes large enough to allow spreading of roots.
- D. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- E. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- F. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.6 PLANTING AREA MULCHING

- A. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 12 inches and secure seams with galvanized pins. Do not employ on areas specified for steep slope groundcover mix. Weed control in these areas will inhibit the desired horizontal rhizome growth of plants.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Trees in Turf Areas: Apply organic mulch ring of 3-inch average thickness, with 24-inch radius around trunks or stems. Do not place mulch within 3 inches of trunks or stems.
 - 2. Decorative Rock Mulch in Planting Areas Adjacent to the Building: Apply 3-inch average thickness of rock mulch over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within 3 inches of tree and shrub trunks or perennial and grass stems.

3.7 EDGING INSTALLATION

- A. Steel Edging: Install steel edging per the plans and details according to manufacturer's written instructions. Anchor with steel stakes spaced approximately 30 inches apart, driven below top elevation of edging.

3.8 INSTALLING SLOW-RELEASE WATERING DEVICE

- A. Provide one device for each tree.

3.9 PLANT MAINTENANCE

- A. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings.
- 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.
- C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices when possible to minimize use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.
- D. Apply pesticides and other chemical products and biological control agents according to 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.
- E. 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.
- F. At time of Substantial Completion, verify that tree-watering devices are in good working order and leave them in place. Replace improperly functioning devices.

3.10 MAINTENANCE SERVICE

- A. Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in "Plant Maintenance" Article. 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 for Trees and Shrubs: 12 months from date of Substantial Completion.
 - 2. Maintenance Period for Ground Cover and Other Plants: 12 months from date of Substantial Completion.

END OF SECTION 329300

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Ductile-iron, gravity sewer pipe and fittings.
3. Ductile-iron, pressure pipe and fittings.
4. PVC pipe and fittings.
5. Nonpressure-type transition couplings.
6. Pressure-type pipe couplings.
7. Expansion joints and deflection fittings.
8. Backwater valves.
9. Cleanouts.
10. Encasement for piping.
11. Manholes.
12. Concrete.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Pipe and fittings.
2. Non-pressure and pressure couplings
3. Backwater valves.
4. Lift Station Product Data
5. Cleanouts.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers and security bolts.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from sewer system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Product Certificates: For each type of pipe and fitting.

C. Field quality-control reports.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, 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.

1.5 FIELD 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 Construction Manager, Owner no fewer than seven days in advance of proposed interruption of service.
 - 2. Do not proceed with interruption of service without Construction Manager's, Owner's written permission.

PART 2 - PRODUCTS

2.1 PVC PIPE AND FITTINGS

- A. PVC Profile Sewer Piping:
 - 1. Pipe: ASTM F794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
 - 2. Fittings: ASTM D3034, PVC with bell ends.
 - 3. Gaskets: ASTM F477, elastomeric seals.
- B. PVC Type PSM Sewer Piping:
 - 1. Pipe: ASTM D3034, SDR 26, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
 - 2. Fittings: ASTM D3034, PVC with bell ends.
 - 3. Gaskets: ASTM F477, elastomeric seals.

2.2 NONPRESSURE-TYPE TRANSITION COUPLINGS

- A. Comply with ASTM C1173, elastomeric, sleeve-type, reducing or transition coupling; for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and include corrosion-resistant-metal tension band and tightening mechanism on each end.
- B. Sleeve Materials:
 - 1. For Cast-Iron Soil Pipes: ASTM C564, rubber.

2. For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
3. For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.

2.3 CLEANOUTS

A. PVC Cleanouts:

1. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details to indicate general location and arrangement of underground sanitary sewer 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 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. 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, at minimum slope of 2 percent unless otherwise indicated.
 2. Install piping with 36-inch minimum cover.
 3. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
 4. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron

Soil Pipe and Fittings Handbook."

5. Install ductile-iron, gravity sewer piping according to ASTM A746.
 6. Install PVC profile sewer piping according to ASTM D2321 and ASTM F1668.
 7. Install PVC Type PSM sewer piping according to ASTM D2321 and ASTM F1668.
 8. Install PVC gravity sewer piping according to ASTM D2321 and ASTM F1668.
- 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, nonpressure, drainage piping according to the following:
1. Join ductile-iron, gravity sewer piping according to AWWA C600 for push-on joints.
 2. Join PVC profile sewer piping according to ASTM D2321 for elastomeric-seal joints or ASTM F794 for gasketed joints.
 3. Join PVC Type PSM sewer piping according to ASTM D2321 and ASTM D3034 for elastomeric-seal joints or ASTM D3034 for elastomeric-gasket joints.
 4. Join PVC gravity sewer piping according to ASTM D2321 and ASTM D3034 for elastomeric-seal joints or ASTM D3034 for elastomeric-gasket joints.
 5. Join dissimilar pipe materials with nonpressure-type, flexible or rigid 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 use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
 2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
 3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 12 by 12 by 6 inches deep. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.
- D. Make connections to existing piping and underground manholes.
1. Use commercially manufactured wye fittings for piping branch connections.

- Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch overlap with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
 - 2. Make branch connections from side into existing piping, NPS 4 to NPS 20. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
 - 3. Make branch connections to underground manholes by cutting opening into existing unit large enough to allow 3 inches of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of, and be flush with, inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches of concrete for minimum length of 24 inches to provide additional support of collar from connection to undisturbed ground.
 - a. Use concrete that will attain a minimum 28-day compressive strength of 3000 psi unless otherwise indicated.
 - b. Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
 - 4. 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.
- E. Connect to grease, oil, and, sand interceptors specified in the project drawings.
 - F. Backfill to grade according to Section 312000 "Earth Moving."
 - G. IDENTIFICATION
 - H. Comply with requirements in Section 312000 "Earth Moving" for underground utility identification devices. Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
 - 1. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.5 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. 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 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.

Testing required for mains only or as directed by the City of Lee's Summit.

- 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. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
 - a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.
 - b. Close openings in system and fill with water.
 - c. Purge air and refill with water.
 - d. Disconnect water supply.
 - e. Test and inspect joints for leaks.
- 6. Manholes: Perform hydraulic test according to ASTM C969.
- 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.
- E. Inspect and video tape sanitary piping using a closed-circuit television camera. Inspections, and any deficiencies found shall be corrected prior to substantial completion. Video tapes of the sanitary sewer piping shall be labeled indicating which section(s) of system are recorded. Original or copies of all inspection tapes shall be provided to the Supervisory Construction Representative. The contractor shall certify that all underground sanitary sewer piping have met installation and design requirements.

3.6 CLEANING

- A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 03 3300

Section 334100 – STORM UTILTIY 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. Section Includes:
 - 1. Pipe and fittings.
 - 2. Junction boxes.
 - 3. Stormwater inlets.

1.3 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.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of pipe and fitting, from manufacturer.
- B. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Do not store plastic manholes, 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.
- D. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 PE PIPE AND FITTINGS

- A. Corrugated PE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
 - 1. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.2 JUNCTION BOXES

- A. Designed Precast Concrete Catch Basins: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated on the plans, with provision for joint sealants.
 - 1. Joint Sealants: ASTM C 990, bitumen or butyl rubber.
 - 2. Steps: Individual FRP steps, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of junction box to finished grade is less than 60 inches.
 - 3. Pipe Connectors: ASTM C 923, resilient, of size required, for each pipe connecting to base section.

2.3 STORMWATER INLETS

- A. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to plans.
- B. Grate Inlets: Made with horizontal grate opening, of materials and dimensions according to plans. Include heavy-duty frames and grates.
- C. Area Inlets: Made with vertical openings, of materials and dimensions according to plans. Include heavy-duty frames and grates.
- D. Frames and Grates: Heavy duty, according to plans.

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 junction boxes 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 piping with 18-inch minimum cover.
 - 3. Install PE corrugated sewer piping according to ASTM D 2321.

3.3 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure drainage piping according to the following:
 - 1. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
 - 2. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.4 JUNCTION BOX INSTALLATION

- A. Construct junction boxes to sizes and shapes indicated.
- B. Set frames and covers to elevations indicated.

3.5 STORMWATER INLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
- B. Install outlets that spill onto grade, anchored with concrete, where indicated.
- C. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
- D. Construct energy dissipaters at outlets, as indicated.

3.6 CONCRETE PLACEMENT

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

3.7 CONNECTIONS

- A. Make connections to existing piping and underground manholes.
 - 1. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.8 IDENTIFICATION

- A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
 - 1. Use warning tape or detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

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 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 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.

3.10 CLEANING

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

END OF SECTION 33 4100