

HAVERHILL ELEMENTARY SCHOOL BID PACKAGE 6 - CONSTRUCTION New Construction

PROJECT MANUAL

6/30/2023

OWNER

PORTAGE PUBLIC SCHOOLS

8107 MUSTANG DRIVE
PORTAGE, MI 49002

PROJECT NUMBER

Architect's Project No. 21237.20

State File No.

State Index No.

SET NUMBER

VOLUME NUMBER 2

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SECTION 21 0500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Sleeve-seal systems.
 - 3. Sleeves.
 - 4. Stack-sleeve fittings.
 - 5. Escutcheons.
 - 6. Grout.
 - 7. Fire-suppression equipment and piping demolition.
 - 8. Equipment installation requirements common to equipment sections.
 - 9. Painting and finishing.
 - 10. Supports and anchorages.
- B. Related Sections:
 - 1. Division 01 Section "Alternates" for requirements of alternates that relate to this Division.

1.2 QUALITY ASSURANCE

- A. Provide fire-suppression systems, equipment, and materials in accordance with NFPA and other applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. 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.
- D. 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.

1.3 DELIVERY, STORAGE, AND HANDLING

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

- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

1.4 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.
- B. Coordinate installation of required supporting devices and sleeves with structural components.
- C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

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.
- C. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 - 1. All castings used for coupling housings, fittings, valve bodies, etc., shall include listing/approval stamp, label, or other markings made to specified standards.

2.2 JOINING MATERIALS

- A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
- B. 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.
 - 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.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3 SLEEVE-SEAL SYSTEMS

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

2.4 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. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.5 STACK-SLEEVE FITTINGS

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

2.6 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.

- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

2.7 GROUT

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

PART 3 - EXECUTION

3.1 FIRE-SUPPRESSION DEMOLITION

- A. Refer to Division 01 Section "Execution" and Division 02 Section "Selective Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.2 PIPING SYSTEMS - COMMON INSTALLATION REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved.
 - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.

- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping 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. Select system components with pressure rating equal to or greater than system operating pressure.

3.3 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
 - 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, cast-brass or split-casting brass type with 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 in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
 - e. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
 - f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - 2. Escutcheons for Existing Piping:
 - a. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - b. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - c. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated or rough-brass finish.
 - d. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated or rough-brass finish.

3.4 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
 - 1. Sleeves are not required for core-drilled holes.

- 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.
- C. Install sleeves in concrete floors, concrete walls and masonry 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, 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 07 9200 "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 07 8413 "Penetration Firestopping."

3.5 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 07 6200 "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 07 8413 "Penetration Firestopping."

3.6 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.

3.7 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: Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves, galvanized-steel wall sleeve, 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.
 - 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.
 - 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.
 - 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.
 - 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: Stack-sleeve fittings.
 - b. Piping NPS 6 and Larger: 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.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of fire suppression equipment.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.
- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.10 PAINTING

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

3.11 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.

3.12 GROUTING

- A. Mix and install grout for fire protection installations.
 - 1. Clean surfaces that will come into contact with grout.
 - 2. Provide forms as required for placement of grout.
 - 3. Avoid air entrapment during placement of grout.
 - 4. Cure placed grout.

3.13 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, dampers or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
 - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
 - 2. Adjust hardware and panels after installation for proper operation.

3.14 FIELD QUALITY CONTROL

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

END OF SECTION 21 0500

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SECTION 21 0513 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION 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 ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

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.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

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

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
 - 1. Provide premium efficient motors where scheduled or when used with a variable frequency controller.
- 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: Manufacturer's standard material.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with controller manufacturer.
1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.

2.5 SINGLE-PHASE MOTORS

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

PROJECT NO. 21237.20 COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT
HAVERHILL ELEMENTARY SCHOOL BID PACKAGE 6 - CONSTRUCTION 21 0513 - 3
PORTAGE PUBLIC SCHOOLS 6/30/2023

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 21 0513

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SECTION 21 1000 – WATER BASED FIRE SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following fire-suppression piping inside the building:
 - 1. Wet-pipe sprinkler systems.
 - 2. Dry-pipe sprinkler systems.
- B. Related Sections include the following:
 - 1. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

1.2 SYSTEM DESCRIPTIONS

- A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.
- B. Dry-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry-pipe valve. Water then flows into piping and discharges from opened sprinklers.

1.3 PERFORMANCE REQUIREMENTS

- A. Standard Piping System Component Working Pressure: Listed for at least 175 psig.
- B. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.
- C. The Architect will review shop drawings as related to piping layout, head layout, head type and color for compliance with the specifications, drawings and architectural intent. It is the responsibility of this contractor to review all drawing within the project manual and coordinate their design and installation with other trades.
 - 1. Maximum Protection Area per Sprinkler: Per UL listing, NFPA, and manufacturers specifications.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Piping materials, including flexible connections and sprinkler specialty fittings.
 - 2. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
 - 3. Air compressors, including electrical data.

4. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
5. Alarm devices, including electrical data.
6. Elevator valve wall box.

B. Shop Drawings: Diagram power, signal, and control wiring.

1. Sprinklers shall be referred to on drawings, submittals and other documentation, by the sprinkler identification or Model number as specifically published in the appropriate agency listing or approval. Trade names or other abbreviated designations shall not be allowed.
2. Grooved joint couplings and fittings shall be referred to on drawings and product submittals, and be identified by the manufacturer's listed model or series designation.

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.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.**
- B. 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" and "Contractor's Material and Test Certificate for Underground Piping."**

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.**

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by a qualified installer experienced in such work; with a minimum of 5 previous projects similar in size and scope to this project; be familiar with all precautions required; and has complied with all the requirements of the authority having jurisdiction.**
1. Installer's responsibilities include designing, fabricating, and installing fire-suppression 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 or NICET Level III or IV certified layout technician.
- B. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:**
1. NFPA 13, "Installation of Sprinkler Systems."
- C. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.**

- D. All castings used for couplings housings, fittings, or valve and specialty bodies shall be date stamped for quality assurance and traceability.

1.8 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.9 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 DUCTILE-IRON PIPE AND FITTINGS

- A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell end and plain end.
 - 1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron gland, rubber gasket, and steel bolts and nuts.
- B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell end and plain end.
 - 1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 - 2. Gaskets: AWWA C111, rubber.
- C. Grooved-End, Ductile-Iron Pipe: AWWA C151, with factory- or field-formed, radius-cut-grooved ends according to AWWA C606.
 - 1. Grooved-Joint Piping Systems:
 - a. Manufacturers:

- 1) Victaulic Co. of America.
- b. Grooved-End Fittings: ASTM A 536, ductile-iron casting with OD matching ductile-iron-pipe OD.
- c. Grooved-End-Pipe Couplings: AWWA C606, gasketed fitting matching ductile-iron-pipe OD. Include ductile-iron housing with keys matching ductile-iron-pipe and fitting grooves, rubber gasket with center leg, and steel bolts and nuts.
- d. Grooved-End-Pipe Transition Coupling: UL 213 and AWWA C606, gasketed fitting with end matching ductile-iron-pipe OD and end matching steel-pipe OD. Include ductile-iron housing with key matching ductile-iron-pipe groove and key matching steel-pipe groove, rubber gasket listed for use with housing, and steel bolts and nuts.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795.

1. Main and line piping NPS 2 and larger to be Schedule 10 grooved.
2. Line piping NPS 1-1/2 and smaller to be Schedule 40 threaded.
 - a. If hydraulically proven, NPS 1-1/4 and NPS 1-1/2 may be Schedule 10.

B. Steel Pipe Fittings:

1. Cast-Iron Threaded Flanges: ASME B16.1.
2. Malleable-Iron Threaded Fittings: ASME B16.3.
3. Gray-Iron Threaded Fittings: ASME B16.4.
4. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe. Include ends matching joining method.
5. Steel Threaded Couplings: ASTM A 865.
6. Locking-Lug Fittings: UL 213, ductile-iron body with retainer lugs that require one-quarter turn to secure pipe in fitting.
7. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
8. Steel Flanges and Flanged Fittings: ASME B16.5.

C. Grooved-Joint Piping Systems:

1. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD. In applicable sizes, fittings shall be short pattern, with flow equal to standard pattern fittings. Basis of Design: Victaulic FireLock.
 - a. Installation-Ready™ fittings for Schedule 40 grooved end steel piping in fire protection applications sizes NPS 1-1/4 thru 2 1/2 (DN 32 thru DN 65). Fittings shall consist of a ductile iron housing with Installation-Ready™ ends, prelubricated Grade "E" EPDM Type 'A' gasket, and ASTM A449 electroplated steel bolts and nuts. UL listed for a working pressure of 300 psi (2065 kPa) and FM approved for working pressure 365 psi (2517kPa).
2. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, pre-lubricated rubber center-leg gasket listed for use with housing with pipe stop to ensure proper groove engagement, alignment, and pipe insertion depth, and ASTM A449 electroplated steel bolts and nuts.
 - a. Rigid Type: Housings cast with offsetting, angle-pattern, bolt pads to provide system rigidity and support and hanging in accordance with NFPA-13, fully installed at visual pad-to-pad

offset contact. (Couplings that require exact gapping at specific torque ratings are not permitted.). Installation-Ready for complete installation without field disassembly. Basis of Design: Victaulic Style 009N and 107N.

- b. Flexible Type: For use in locations where vibration attenuation and stress relief are required: Basis of Design: Victaulic Installation-Ready Style 177.
- 3. Gaskets: Material, thickness, and type suitable for intended service and design system temperatures and pressures.

2.4 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping.
- B. Outlet Specialty Fittings:
 - 1. Manufacturers:
 - a. Anvil International, Inc.
 - b. Ductilic, Inc.
 - c. JDH Pacific, Inc.
 - d. National Fittings, Inc.
 - e. Shurjoint Piping Products, Inc.
 - f. Southwestern Pipe, Inc.
 - g. Victaulic Co. of America.
 - h. Ward Manufacturing.
 - 2. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.
 - 3. Snap-On and Strapless Outlet Fittings: UL 213, ductile-iron housing or casting with gasket and threaded outlet.
 - 4. Basis of Design: Victaulic Style 920 / 920N.
- C. Sprinkler Drain and Alarm Test Fittings: Cast-bronze or ductile-iron body; with threaded, grooved, or locking-lug inlet and outlet, test valve, and orifice and sight glass.
 - 1. Manufacturers:
 - a. Fire-End and Croker Corp.
 - b. Viking Corp.
 - c. Victaulic Co. of America.
 - 2. Basis of Design: Victaulic 747.
- D. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
 - 1. Manufacturers:
 - a. Elkhart Brass Mfg. Co., Inc.
 - b. Fire-End and Croker Corp.
 - c. Potter-Roemer; Fire-Protection Div.

- E. Sprinkler Inspector's Test Fitting: Cast-bronze or ductile-iron housing with threaded or grooved inlet and drain outlet and sight glass.
1. Manufacturers:
 - a. AGF Manufacturing Co.
 - b. G/J Innovations, Inc.
 - c. Triple R Specialty of Ajax, Inc.
 2. Basis of Design: Victaulic Style 720 TestMaster™ II
- F. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.
1. Manufacturers:
 - a. CECA, LLC.
 - b. Merit.
- G. Flexible, Sprinkler Hose Fittings:
1. Manufacturers:
 - a. Victaulic Co.
 2. Standard: UL 2443 and FM 1637.
 3. Type: Fully stainless steel flexible hose for connection to sprinkler, and with one-piece open-gate "Series AB1" bracket for connection to ceiling grid. Bracket to allow for installation before ceiling tile is in place.
 4. Hose: UL approved Series AH2 or AH2-CC braided hose with a bend radius to 2 Inch (53 mm) for proper installation in confined spaces.
 5. Pressure Rating: 175-psig (1200-kPa) minimum.
 6. Size: Same as connected piping, for sprinkler.
 7. Basis of Design: Victaulic Vic-Flex.
 8. In lieu of rigid connections to dry sprinkler heads, a Victaulic VicFlex™ dry sprinkler, Model VS1, may be used. The sprinkler shall provide a vertical or horizontal flexible connection with a bend radius to 2", and allow for up to 4 bends.
 9. In lieu of rigid pipe offsets or return bends for sprinkler drops in wet systems in cold storage applications, the Victaulic VicFlex™ V33, V36, or V40 Dry Sprinkler with Integral AB6 Assembly may be used.
 10. In lieu of threaded steel piping systems, the Victaulic FireLock IGS System with "Installation-Ready™" fittings and couplings may be used for NPS 1 (DN 25) Schedule 10 and Schedule 40 carbon steel pipe in fire protection applications. System rated for a working pressure to 365 psi (2517 kPa).
 - a. Groove: IGS "Innovative Groove System" groove with shortened "A" dimension and tapered groove backside for ease of installation.
 - b. Grooving Tool: Victaulic RG2100, with IGS Confirmation Gauge.
 - c. UL listed and FM approved rigid coupling to join sprinklers with IGS profile grooved ends to matching 1" IGS outlets; Coupling consists of two cast copper-alloy housing segments for connection of ½", ¾", and 1" sprinklers. Coupling includes an EPDM Type A gasket, with zinc-plated cap screws conforming to ASTM F835, and nylon insert locknut. Installation-ready, for direct push installation without field disassembly. Rated for a working pressure to 175 psi (1205 kPa). Victaulic Model V9.
- H. Dry-Pipe-System Fittings: UL listed for dry-pipe service.

2.5 LISTED FIRE-PROTECTION VALVES

- A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating.
- B. Ball Valves: Comply with UL 1091, except with ball instead of disc.
 - 1. NPS 1-1/2 and Smaller: Bronze or brass body with threaded ends.
 - 2. NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
 - 3. NPS 3: Ductile-iron body with grooved ends.
 - 4. Manufacturers:
 - a. NIBCO.
 - b. Victaulic Co. of America.
- C. Butterfly Valves: UL 1091.
 - 1. NPS 2 and Smaller: Bronze body with threaded ends.
 - a. Manufacturers:
 - 1) Milwaukee Valve Company.
 - 2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.
 - a. Manufacturers:
 - 1) McWane, Inc.; Kennedy Valve Div.
 - 2) Mueller Company.
 - 3) NIBCO.
 - 4) Pratt, Henry Company.
 - 5) Victaulic Co. of America.
 - b. Basis of Design: Victaulic Series 608N and Series 705.
- D. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
 - 1. Manufacturers:
 - a. AFAC Inc.
 - b. American Cast Iron Pipe Co.; Waterous Co.
 - c. Clow Valve Co.
 - d. Crane Co.; Crane Valve Group; Crane Valves.
 - e. Crane Co.; Crane Valve Group; Jenkins Valves.
 - f. Firematic Sprinkler Devices, Inc.
 - g. Globe Fire Sprinkler Corporation.
 - h. Hammond Valve.
 - i. Matco-Norca, Inc.
 - j. McWane, Inc.; Kennedy Valve Div.
 - k. Mueller Company.
 - l. NIBCO.
 - m. Potter-Roemer; Fire Protection Div.
 - n. Reliable Automatic Sprinkler Co., Inc.
 - o. Stockham.
 - p. United Brass Works, Inc.
 - q. Venus Fire Protection, Ltd.
 - r. Victaulic Co. of America.
 - s. Watts Industries, Inc.; Water Products Div.

2. Basis of Design: Victaulic Series 717.
- E. Gate Valves: UL 262, OS&Y type.
1. NPS 2 and Smaller: Bronze body with threaded ends.
 - a. Manufacturers:
 - 1) Crane Co.; Crane Valve Group; Crane Valves.
 - 2) Hammond Valve.
 - 3) NIBCO.
 - 4) United Brass Works, Inc.
 2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.
 - a. Manufacturers:
 - 1) Clow Valve Co.
 - 2) Crane Co.; Crane Valve Group; Crane Valves.
 - 3) Crane Co.; Crane Valve Group; Jenkins Valves.
 - 4) Hammond Valve.
 - 5) Milwaukee Valve Company.
 - 6) Mueller Company.
 - 7) NIBCO.
 - 8) Red-White Valve Corp.
 - 9) United Brass Works, Inc.
3. Basis of Design: Victaulic Series 771.
- F. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
1. Indicator: Indicator: Electrical, 115-V ac, prewired, single-circuit, supervisory switch.
 2. NPS 2 and Smaller: Ball or butterfly valve with bronze or brass body and threaded or grooved ends.
 - a. Manufacturers:
 - 1) Milwaukee Valve Company.
 - 2) NIBCO.
 - 3) Victaulic Co. of America.
 - b. Basis of Design: Victaulic Series 728.
 3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.
 - a. Manufacturers:
 - 1) Central Sprinkler Corp.
 - 2) Grinnell Fire Protection.
 - 3) McWane, Inc.; Kennedy Valve Div.
 - 4) Milwaukee Valve Company.
 - 5) NIBCO.
 - 6) Victaulic Co. of America.
 - b. Basis of Design: Victaulic Series 705.

2.6 UNLISTED GENERAL-DUTY VALVES

- A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.
- B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.
- C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.
- D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.7 SPECIALTY VALVES

- A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating.
- B. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.
 - 1. Manufacturers:
 - a. AFAC Inc.
 - b. Firematic Sprinkler Devices, Inc.
 - c. Globe Fire Sprinkler Corporation.
 - d. Reliable Automatic Sprinkler Co., Inc.
 - e. Venus Fire Protection, Ltd.
 - f. Victaulic Co. of America.
 - g. Viking Corp.
 - 2. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, and fill-line attachment with strainer.
 - a. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
 - b. Valve internal components shall be replaceable without removal of valve from installed position.
 - c. Basis of Design: Vicatubic Series 751 (with Series 752 retarding chamber).
 - 3. Dry-Pipe Valves: UL 260, differential type; with bronze seat with O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment. Valve internal components shall be replaceable without removal of valve from installed position. Valve shall be externally re-settable.
 - a. Air-Pressure Maintenance Device: UL 260, automatic device to maintain correct air pressure in piping. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig maximum inlet pressure.

- 1) Manufacturers:
 - a) Victaulic Co.
 - 2) Basis of Design: Victaulic Series 768N.
 - b. Air Compressor: UL 753, fractional horsepower, 120-V ac, 60 Hz, single phase.
 - 1) Manufacturers:
 - a) Victaulic Co.
 - 2) Basis of Design: Victaulic Series 7C7.
- C. Pressure-Regulating Valves: UL 1468, brass or bronze, NPS 1-1/2 and NPS 2-1/2, 400-psig minimum rating. Include female NPS inlet and outlet, adjustable setting feature, and straight or 90-degree-angle pattern design as indicated.
 1. Manufacturers:
 - a. AFAC Inc.
 - b. Elkhart Brass Mfg. Co., Inc.
 - c. Fire-End and Croker Corp.
 - d. GMR International Equipment Corporation.
 - e. Potter-Roemer; Fire Protection Div.
 - f. Zurn Industries, Inc.; Wilkins Div.
- D. Automatic Drain Valves: UL 1726, NPS 3/4, ball-check device with threaded ends.
 1. Manufacturers:
 - a. AFAC Inc.
- E. Universal Manifold Check Assembly:
 1.
 1. Manufacturers:
 - a. Globe Fire Sprinkler.
 2. Standard: UL Listed and FM Approved.
 3. Pressure Rating: Universal manifold check valve shall be rated for use at the maximum service pressure of 300 psi.
 4. Type: Horizontal or Vertical installation.
 5. Body Material: Ductile iron construction, incorporating a control valve, check valve, flow switch, test & drain assembly, adjustable relief valve, and system gauges in one compact body/footprint, and shall be manufactured for "right" and "left"-hand orientations. The test & drain assembly shall contain an adjustable relief valve, with a range of 175 to 310 psi.
 6. End Connections: Threaded or Grooved.
 7. Basis of Design: Globe Model UMC.
- F. Universal Manifold Assembly:
 1. Manufacturers:
 - a. Globe Fire Sprinkler.
 2. Standard: UL Listed and FM Approved.
 3. Pressure Rating: Universal manifold check valve shall be rated for use at the maximum service pressure of 300 psi.
 4. Type: Horizontal or Vertical installation.

5. Body Material: Ductile iron construction, incorporating a control valve, flow switch, test & drain assembly, adjustable relief valve, and system gauges in one compact body/footprint, and shall be manufactured for "right" and "left"-hand orientations. The test & drain assemble shall contain an adjustable relief valve, with a range of 175 to 310 psi.
6. End Connections: Threaded or Grooved.
7. Basis of Design: Globe Model UM.

2.8 SPRINKLERS

- A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating.
- B. Manufacturers:
 1. Tyco.
 2. Globe Fire Sprinkler Corporation.
 3. Reliable Automatic Sprinkler Co., Inc.
 4. Venus Fire Protection, Ltd.
 5. Victaulic Co. of America.
 6. Viking Corp.
- C. Automatic Sprinklers: With heat-responsive element complying with the following:
 1. UL 199, for nonresidential applications.
 2. UL 1767, for early-suppression, fast-response applications.
- D. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
 1. Open Sprinklers: UL 199, without heat-responsive element.
 - a. Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8.
 - b. Orifice: 17/32 inch, with discharge coefficient K between 7.4 and 8.2.
- E. Sprinkler types, features, and options as follows:
 1. Concealed ceiling sprinklers, including cover plate.
 2. Extended-coverage sprinklers.
 3. Pendent sprinklers.
 4. Pendent, dry-type sprinklers.
 5. Quick-response sprinklers.
 6. Recessed sprinklers, including escutcheon.
 7. Sidewall sprinklers.
 8. Sidewall, dry-type sprinklers.
 9. Upright sprinklers.
- F. Coordination: Review all drawings in this set for Sprinkler type, features and options.
- G. Sprinkler Finishes: Chrome plated, bronze, painted Review Architectural reflective ceiling plans for specific requirements.
- H. Special Coatings: Wax, lead, and corrosion-resistant paint.

- I. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- J. Escutcheons and guards shall be listed, supplied and approved for use with the sprinkler by the sprinkler manufacturer.
- K. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler shall be provide in Gym and areas where head could be subjected to impact due to the activities being held.
- L. Use of flexible drop sprinklers is acceptable upon approval of product specification.
 - 1. Braided lines required for FMG protects.
- M. Wrenches shall be provided by the sprinkler manufacturer that directly engage the wrench boss cast in the sprinkler body.

2.9 FIRE DEPARTMENT CONNECTIONS

- A. Available Manufacturers:
 - 1. Central Sprinkler Corp.
 - 2. Elkhart Brass Mfg. Co., Inc.
 - 3. Fire-End and Croker Corp.
 - 4. Fire Protection Products, Inc.
 - 5. GMR International Equipment Corporation.
 - 6. Guardian Fire Equipment Incorporated.
 - 7. Potter-Roemer; Fire-Protection Div.
 - 8. Reliable Automatic Sprinkler Co., Inc.
 - 9. United Brass Works, Inc.
- B. Wall-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR & STANDPIPE."
 - 1. Type: Flush, with two inlets and square or rectangular escutcheon plate.
 - 2. Type: Exposed, projecting, with two inlets and round escutcheon plate.
 - 3. Finish: Rough chrome-plated.
- C. At the low point near each fire department connection, install a 90-degree elbow with drain connection to allow for localized system drainage to prevent freezing. Basis of Design: Victaulic #10-DR.

2.10 ALARM DEVICES

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

B. Horn Strobe Alarm:

1. The horn strobe shall be listed to UL 1971 and UL 464 suitable for outdoor mounting and shall be approved for fire protective service. The horn strobe shall be wired as a primary-signaling notification appliance and comply with the Americans with Disabilities Act requirements for visible signaling appliances, flashing at 1Hz over the strobe's entire operating voltage range.
2. The horn strobe shall mount to a standard back box with a universal mounting plate. The notification appliance circuit wiring shall terminate at the universal mounting plate.

C. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include 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.

1. Manufacturers:
 - a. ADT Security Services, Inc.
 - b. ITT McDonnell & Miller.
 - c. Potter Electric Signal Company.
 - d. System Sensor.
 - e. Viking Corp.
 - f. Watts Industries, Inc.; Water Products Div.

D. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.

1. Manufacturers:
 - a. Potter Electric Signal Company.
 - b. System Sensor.
 - c. Viking Corp.

E. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

1. Manufacturers:
 - a. McWane, Inc.; Kennedy Valve Div.
 - b. Potter Electric Signal Company.
 - c. System Sensor.

F. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

1. Manufacturers:
 - a. Potter Electric Signal Company.
 - b. System Sensor.

2.11 PRESSURE GAGES

A. Manufacturers:

1. AGF Manufacturing Co.
2. AMETEK, Inc.; U.S. Gauge.
3. Brecco Corporation.
4. Dresser Equipment Group; Instrument Div.
5. Marsh Bellofram.
6. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of 0 to 300 psig.

1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

2.12 ELEVATOR VALVE RECESSED WALL BOXES

A. Cabinet: Suitable for shut-off valve with supervisory switch.

1. Cabinet Construction: Fire-rated with rating equal to wall installed in.
 - a. Non-rated Wall: Non-rated construction
 - b. Rated Wall: Fire-rated with rating equal to wall installed in
2. Cabinet Material: Steel sheet.
3. Recessed Cabinet: Cabinet box recessed in walls of sufficient depth to suit shut-off valve.
 - a. Exposed Flat Trim: One-piece combination trim and perimeter door frame overlapping surrounding wall surface with exposed trim face and wall return at outer edge (backbend).
4. Cabinet Trim Material: Same material and finish as door.
5. Door Material: Steel sheet.
6. Door Hardware: Manufacturer's standard door-operating hardware of proper type for cabinet type, trim style, and door material.
 - a. Provide projecting door pull and friction latch.
 - b. Provide concealed hinge permitting door to open 180 degrees.
7. Accessories:
 - a. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location.
 - 1) Identify valve located in cabinet.
8. Finishes: Manufacturer's standard baked-enamel paint.

PART 3 - EXECUTION

3.1 PREPARATION

- A. If a flow test at the nearest outside fire hydrant is older than two (2) years from the date of the calculations, perform a new fire-hydrant flow test according to NFPA 13 and NFPA 291.**

- B. Report test results promptly and in writing.

3.2 PIPING APPLICATIONS, GENERAL

- A. Shop weld pipe joints where welded piping is indicated.
- B. Do not use welded joints for galvanized-steel pipe.
- C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.
- D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with cast- or malleable-iron threaded fittings and threaded joint; or grooved-end fittings, pipe couplings; and grooved joints.
- E. Underground Service-Entrance Piping: Ductile-iron, mechanical-joint pipe and fittings and restrained joints or ductile-iron, grooved-end pipe and fittings; grooved-end-pipe couplings; and grooved joints.

3.3 SPRINKLER SYSTEM PIPING APPLICATIONS

- A. Standard-Pressure, Wet-Pipe Sprinkler System, 175-psig Maximum Working Pressure:
 - 1. NPS 2 and Smaller: Black steel pipe with any of the following joints:
 - a. Cast- or malleable-iron threaded fittings; and threaded joints.
 - b. Locking-lug fittings; and twist-locked joints.
 - c. Grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
 - 2. NPS 2-1/2 and Larger: Black steel pipe with any of the following joints:
 - a. Cast- or malleable-iron threaded fittings; and threaded joints.
 - b. Steel welding fittings; and welded joints.
 - c. Grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
- B. Standard-Pressure, Dry-Pipe Sprinkler System, 175-psig Maximum Working Pressure:
 - 1. NPS 2 and Smaller: Galvanized steel pipe with any of the following joints:
 - a. Galvanized cast- or malleable-iron threaded fittings; and threaded joints.
 - b. Galvanized locking-lug fittings; and twist-locked joints.
 - c. Galvanized grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
 - 2. NPS 2-1/2 and Larger: Galvanized steel pipe with any of the following joints:
 - a. Cast- or malleable-iron threaded fittings; and threaded joints.
 - b. Grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.4 VALVE APPLICATIONS

- A. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13.
 - 1. Shutoff Duty: Use ball, butterfly, or gate valves.

- B. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13.

1. Shutoff Duty: Use ball, butterfly, or gate valves.
2. Throttling Duty: Use ball or globe valves.

3.5 JOINT CONSTRUCTION

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.
- B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.
- C. Twist-Locked Joints: Insert plain-end piping into locking-lug fitting and rotate retainer lug one-quarter turn.
- D. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts in accordance with the manufacturer's latest published instructions.
1. Ductile-Iron Pipe: Radius-cut-groove ends of piping. Use grooved-end fittings and grooved-end-pipe couplings.
 2. Steel Pipe: Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
 3. Dry-Pipe Systems: Use fittings and gaskets listed for dry-pipe service.
 4. Gaskets shall be molded and produced by the grooved coupling manufacturer.
 5. Grooved coupling manufacturer's factory trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools, application of groove, and installation of grooved piping products. The factory trained representative shall periodically visit the jobsite to ensure best practices in grooved product installation are being followed. Contractor shall remove and replace any improperly installed products.

3.6 SERVICE-ENTRANCE PIPING

- A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building.
- B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories at connection to water-service piping as required by authorities having jurisdiction.

3.7 PIPING INSTALLATION

- A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.
- B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

- C. Install underground ductile-iron service-entrance piping according to NFPA 24 and with restrained joints.
- D. Use approved 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. Unions are not required on flanged devices or in piping installations using grooved joints.
- F. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.
- G. Unions or flanges for servicing and disconnect are not required in installations using grooved joint couplings.
- H. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.
- I. Install sprinkler piping with drains for complete system drainage.
- J. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.
- K. Install alarm devices in piping systems.
- L. Hangers and Supports: Comply with NFPA 13 for hanger materials.
 - 1. Install sprinkler system piping according to NFPA 13.
- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- N. Drain dry-pipe sprinkler piping.
- O. Pressurize and check dry-pipe sprinkler system piping and air compressors.
- P. Fill wet-pipe sprinkler system piping with water.

3.8 VALVE INSTALLATION

- A. Install listed fire-protection valves, unlisted general-duty 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. Specialty Valves:

1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.
2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.
 - a. Install air compressor and compressed-air supply piping.

3.9 SPRINKLER APPLICATIONS

- A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
 1. Rooms without Ceilings: Upright sprinklers.
 2. Rooms with Suspended Ceilings: Recessed sprinklers.
 3. Wall Mounting: Sidewall sprinklers.
 4. Spaces Subject to Freezing (Attic): Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as required by application.
 5. Spaces Subject to Freezing Kitchen Freezer and Cooler): Dry pendent sprinklers.
 6. Special Applications: Extended-coverage, flow-control, and quick-response sprinklers.
 7. Sprinkler Finishes:
 - a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
 - b. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.

3.10 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels and tiles.
- B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.
- C. Install institutional sprinklers with retaining flange.
- D. Do not install sprinklers that have been dropped, damaged, show a visible loss of fluid, or a cracked bulb.
- E. The sprinkler bulb protector shall be removable by hand, without tools or devices that may damage the bulb.

3.11 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install wall-type, fire department connections in vertical wall or freestanding-type, fire department connections in level surface as indicated.
 1. Install protective pipe bollards on two sides of each freestanding-type fire department connection. Refer to Division 05 Section "Metal Fabrications" for pipe bollards.
- B. Install ball drip valve at each check valve for fire department connection.

3.12 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- D. Connect piping to specialty valves, specialties, fire department connections, and accessories.
- E. Connect compressed-air supply to dry-pipe sprinkler piping.
- F. Connect air compressor to the following piping and wiring:
 - 1. Pressure gages and controls.
 - 2. Electrical power system.
 - 3. Fire alarm devices, including low-pressure alarm.
- G. Electrical Connections: Power wiring is specified in Division 26.
- H. Connect alarm devices to fire alarm.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- K. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.13 LABELING AND IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

3.14 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Energize circuits to electrical equipment and devices.
 - 4. Start and run air compressors.
 - 5. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 6. Coordinate with fire alarm tests. Operate as required.
 - 7. Verify that equipment hose threads are same as local fire department equipment.
- B. Report test results promptly and in writing to Construction Manager and authorities having jurisdiction.

3.15 CLEANING AND PROTECTION

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.
- C. Protect sprinklers from damage until Substantial Completion.

3.16 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 21 1000

SECTION 22 0500 - COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Sleeve-seal systems.
4. Sleeves.
5. Stack-sleeve fittings.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

B. Related Sections:

1. Division 01 Section "Alternates" for requirements of alternates that relate to this Division.

1.2 ACTION SUBMITTALS

A. Product Data: For dielectric fittings.

1.3 QUALITY ASSURANCE

- A. Provide plumbing systems, equipment, and materials in accordance with applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. 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.
- D. Electrical Characteristics for Plumbing 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.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
- C. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

1.5 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- B. Coordinate installation of required supporting devices and sleeves in structural components.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.6 PROJECT COMMISSIONING

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

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

2.2 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BA91, silver alloy for refrigerant piping, unless otherwise indicated.

- F. Solvent Cements for Joining Plastic Piping:

- 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 DIELECTRIC FITTINGS

- A. Dielectric Connections: Ground joint, copper unions, ASME B16.18, cast-copper-alloy body, hexagonal stock, with ball-and-socket joint, metal-to-metal seating surfaces, and solder-joint, threaded, or solder-joint and threaded ends; and suitable system fluid, pressure and temperature.
- B. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150-psig minimum working pressure as required to suit system pressures.
- C. Description: Combination fitting of copper alloy and ferrous materials with threaded end connections that match piping system materials.
 - 1. Insulating Material: Suitable for system fluid, pressure, and temperature.
- D. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F with threaded end connections.
- E. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

2.4 SLEEVE-SEAL SYSTEMS

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

2.5 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. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.6 STACK-SLEEVE FITTINGS

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

2.7 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.
- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

2.8 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.

2.9 PLUMBING ROOF PENETRATIONS

- A. Pipe Curbs for Single or Multiple Pipe Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, wood nailer, and acrylic clad ABS plastic cover(s), PVC boot(s), and stainless steel clamps.. Size as required to suit roof opening and piping. Overall minimum height shall be 12 inches above roof insulation. Pate or equivalent.
 - 1. Provide curbs with level tops and bottoms to match roof slope.
- B. Pipe Curbs for Single Pipe Penetrations: All roof pipe penetrations up to 10" O.D. shall be flashed and sealed using a Pate or equivalent pipe seal, consisting of a spun aluminum base having a minimum five inch roof surface flange, a stepped polyvinyl chloride boot to be secured to the base and the pipe with adjustable stainless steel clamps as furnished.
 - 1. Provide curbs with bottoms to match roof slope.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
 - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping 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.

3.2 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.
 - g. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated or rough-brass finish.

3.3 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
 - 1. Sleeves are not required for core-drilled holes.
- 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.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch 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 07 9200 "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 07 8413 "Penetration Firestopping."

3.4 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 07 6200 "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 07 8413 "Penetration Firestopping."

3.5 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.

3.6 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: Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves, galvanized-steel wall sleeve, 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.
 - 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.
 - 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.
 - 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.
 - 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: Stack-sleeve fittings.
 - b. Piping NPS 6 and Larger: 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.

3.7 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs.
- 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. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-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 Nonpressure Piping: Join according to ASTM D 2855.
- I. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.8 PIPING CONNECTIONS

- A. 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. Wet Piping Systems: Connect piping materials of dissimilar metals as follows:
 - a. In piping NPS 2(DN 50) and smaller, install ground joint unions.
 - b. In piping NPS 2-1/2(DN 65) and larger, install dielectric flanges.
 4. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
 5. Wet Piping Systems: Install dielectric unions, dielectric coupling, or dielectric nipple fittings to connect piping materials of dissimilar metals.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of plumbing equipment.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.
- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.10 PAINTING

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

3.11 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches 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 for cast-in-place concrete."

3.12 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 plumbing materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.13 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
 1. Clean surfaces that will come into contact with grout.
 2. Provide forms as required for placement of grout.
 3. Avoid air entrapment during placement of grout.
 4. Place grout, completely filling equipment bases.
 5. Place grout on concrete bases and provide smooth bearing surface for equipment.
 6. Place grout around anchors.
 7. Cure placed grout.

3.14 PLUMBING ROOF PENETRATIONS

- A. Install plumbing roof penetrations in accordance with roof curb manufacturer's recommendations and in strict compliance with roofing manufacturer's requirements.
 1. Roofs with Warranty: Roof penetrations and curbs shall be installed in such a manner to maintain roofing warranty.
- B. Pipe Curbs for Pipe Penetrations: Secure boot to curb base and secure boot to pipe with adjustable stainless steel clamps.

3.15 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
 - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
 - 2. Adjust hardware and panels after installation for proper operation.

3.16 FIELD QUALITY CONTROL

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

END OF SECTION 22 0500

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SECTION 22 0513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory.

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.
- B. For motors using variable frequency controller, motors to be designed for such application and suitable for use throughout speed range without overheating.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
 - 1. Provide premium efficient motors where scheduled or when used with a variable frequency controller.
- 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. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Class B.
- H. Insulation: Class F.
- I. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Manufacturer's standard material.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with controller.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Shaft Grounding Ring: Factory installed shaft grounding ring consisting of maintenance free, circumferential, bearing protection ring with conductive micro fiber shaft contacting material.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
 2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 ELECTRONIC COMMUTATION MOTOR (ECM)

- A. Description: Motor to be an electronic commutation motor (ECM) specifically designed for direct drive applications. Motors shall be permanently lubricated with heavy-duty ball bearings to match the equipment load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 22 0513

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SECTION 22 0516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Rubber union connector packless expansion joints.
 - 2. Metal-bellows packless expansion joints.
 - 3. Externally pressurized metal-bellows packless expansion joints.
 - 4. Rubber packless expansion joints.
 - 5. Flexible-hose packless expansion joints.
 - 6. Alignment guides and anchors.
 - 7. Pipe loops and swing connections.

1.3 DEFINITIONS

- A. BR: Butyl rubber.
- B. Buna-N: Nitrile rubber.
- C. CR: Chlorosulfonated polyethylene synthetic rubber.
- D. CSM: Chlorosulfonyl-polyethylene rubber.
- E. EPDM: Ethylene-propylene-diene terpolymer rubber.
- F. NR: Natural rubber.

1.4 PERFORMANCE REQUIREMENTS

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

1.5 ACTION SUBMITTALS

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

- B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for 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.

1.6 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Product Certificates: For each type of expansion joint, from manufacturer.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.8 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. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

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 EXPANSION JOINTS

A. Rubber Union Connector Expansion Joints RUEJ-01:

1. Material: Twin reinforced-rubber spheres.
2. Material: Twin reinforced-rubber spheres with external restraining cables.
3. Minimum Pressure Rating: 150 psig at 170 deg F, unless otherwise indicated.
4. Minimum Pressure Rating: 150 psig at 170 deg F, unless otherwise indicated.
5. End Connections for NPS 2 and Smaller: Threaded.

B. Metal-Bellows Packless Expansion Joints MBEJ-01:

1. <Double click here to find, evaluate, and insert list of manufacturers and products.>
2. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
3. Type: Circular, corrugated bellows with external tie rods.
4. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
5. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
6. Configuration: Single joint class(es), unless otherwise indicated.
7. Expansion Joints for Copper Tubing: Single- or multi- ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
 - a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint.
 - c. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint.
 - d. End Connections for Copper Tubing NPS 5 and Larger: Flanged.
8. Expansion Joints for Steel Piping: Single- or multi- ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
 - b. End Connections for Steel Pipe NPS 2-1/2 and Larger: Welded.

C. Externally Pressurized Metal-Bellows Packless Expansion Joints:

1. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
2. Description:
 - a. Totally enclosed, externally pressurized, multi-ply, stainless-steel bellows isolated from fluid flow by an internal pipe sleeve.
 - b. Carbon-steel housing.
 - c. Drain plugs and lifting lug for NPS 3 and larger.
 - d. Bellows shall have operating clearance between the internal pipe sleeves and the external shrouds.
 - e. Joints shall be supplied with a built-in scale to confirm the starting position and operating movement.
 - f. Joint Axial Movement: 4 inches of compression and 0.75 inch of extension.
3. Permanent Locking Bolts: Set locking bolts to maintain joint lengths during installation. Temporary welding tabs that are removed after installation in lieu of locking bolts are not acceptable.
4. End Connection Configuration: Flanged; one raised, fixed and one floating flange.

D. Flexible-Hose Packless Expansion Joints FHEJ-01:

1. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
2. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
3. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
4. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
5. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
6. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with or [welded end connections].
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
7. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with welded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides AG-01:

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 A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, 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 C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

- b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
- c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
- B. Install rubber packless expansion joints according to FSA-PSJ-703.
- C. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
- D. Install expansion joints of sizes matching size of piping in which they are installed.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
1. Anchor Attachment to Steel Structural Members: Attach by welding.
 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 22 0516

SECTION 22 0519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Thermometers.
 - 2. Gages.
- B. Related Sections:
 - 1. Division 22 Section "Facility Water Distribution Piping" for domestic and fire-protection water service meters outside the building.
 - 2. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

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

1. Ashcroft Inc.
2. Blue Ribbon Corp.
3. Ernst Flow Industries.
4. Marsh Bellofram.
5. Miljoco Corporation.
6. Nanmac Corporation.
7. Noshok.
8. Palmer Wahl Instrumentation Group.
9. REOTEMP Instrument Corporation.
10. Tel-Tru Manufacturing Company.
11. Terice, H. O. Co.
12. WATTS.
13. Weiss Instruments, Inc.
14. Weksler Glass Thermometer Corp.
15. WIKA Instrument Corporation.
16. Winters Instruments - U.S.

B. Case: Metal or plastic, 9 inches long.

C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass or plastic.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES.
5. Type: Stepped shank unless straight or tapered shank is indicated.

6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

C. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

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

1. Ametek U.S. Gauge.
2. Ashcroft Inc.
3. Blue Ribbon Corp.
4. Ernst Flow Industries.
5. Flo Fab Inc.
6. Marsh Bellofram.
7. Miljoco Corporation.
8. Noshok.
9. Palmer Wahl Instrumentation Group.
10. REOTEMP Instrument Corporation.
11. Tel-Tru Manufacturing Company.
12. Terice, H. O. Co.
13. WATTS.
14. Weiss Instruments, Inc.
15. Weksler Glass Thermometer Corp.
16. WIKA Instrument Corporation.
17. Winters Instruments - U.S.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Standard: ASME B40.100.
2. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.
3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
4. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer with front recalibration.
6. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
7. Pointer: Red or other dark-color metal.
8. Window: Glass or plastic.
9. Ring: Metal.
10. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
11. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
12. Range for Fluids under Pressure: Two times operating pressure.

2.4 GAGE ATTACHMENTS

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

PART 3 - EXECUTION

3.1 INSTALLATIONS

- A. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- E. Fill thermowells with heat-transfer medium.
- F. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
 - 1. Provide elbows as required to install gauges at location and angle readable from standing position on floor.
- G. Install valve and snubber in piping for each pressure gage for fluids.
- H. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlets and outlets of each domestic water heat exchanger.
 - 3. Inlet and outlet of each domestic hot-water storage tank.
 - 4. Inlet and outlet of each remote domestic water chiller.
 - 5. .
- I. Install pressure gages in the following locations:
 - 1. Building water service entrance into building.
 - 2. Inlet and outlet of each pressure-reducing valve.
 - 3. Suction and discharge of each domestic water pump.
 - 4. .

3.2 CONNECTIONS

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

3.3 ADJUSTING

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

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each domestic water heater shall be the following:
- B. Thermometers at inlet and outlet of each domestic water heater shall be one of the following:
 - 1. Plastic case, industrial-style, liquid-in-glass type.
- C. Thermometers at inlets and outlets of each domestic water heat exchanger shall be the following:
- D. Thermometers at inlets and outlets of each domestic water heat exchanger shall be one of the following:
 - 1. Plastic case, industrial-style, liquid-in-glass type.
 - 2. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.
- E. Thermometers at inlet and outlet of each domestic hot-water storage tank shall be the following:
 - 1. Plastic case, industrial-style, liquid-in-glass type.
 - 2. Test plug with self-sealing rubber inserts.
- F. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

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

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each water service into building shall be the following:
 - 1. Sealed, direct-mounted, plastic case.
 - 2. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.
- B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:
 - 1. Sealed, direct-mounted, plastic case.
 - 2. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

- C. Pressure gages at suction and discharge of each domestic water pump shall be the following:
 - 1. Sealed, direct-mounted, plastic case.
 - 2. Test plug with chlorosulfonated polyethylene synthetic or EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE 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 22 0519

SECTION 22 0523 – GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Bronze ball valves.
 - 2. Iron, lug type butterfly valves.
 - 3. Bronze swing check valves.
 - 4. Iron swing check valves.
 - 5. Iron swing check valves with closure control.
 - 6. Iron gate valves.
 - 7. Lubricated plug valves.
- B. Related Sections:
 - 1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. NRS: Nonrising stem.
- E. OS&Y: Outside screw and yoke.
- F. RS: Rising stem.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve indicated.
 - 1. Certification that products comply with NSF 61 Annex G and NSF 372.

1.5 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 2. ASME B31.9 for building services piping valves.
- C. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect valve ends from damage.
 - 3. Set ball valves open to minimize exposure of functional surfaces.
 - 4. Set butterfly valves closed or slightly open.
 - 5. Block check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. Refer to valve schedule articles for applications of valves.
- C. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B16.18 for solder joint.

5. ASME B31.9 for building services piping valves.
- D. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.
- E. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- F. Bronze valves shall be made with dezincification-resistant materials. Bronze valves made with copper alloy (brass) containing more than 15 percent zinc are not permitted.
- G. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- H. Valve Sizes: Same as upstream piping unless otherwise indicated.
- I. Valve Bypass and Drain Connections: MSS SP-45.
- J. Valve Actuator Types:
 1. Handwheel: For valves other than quarter-turn types.
 2. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
 3. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 3 plug valves, for each size square plug-valve head.
- K. Valves in Insulated Piping: Valves in domestic cold water lines with more than 1/2-inch insulation shall include the following:
 1. Ball Valves: Stem extensions or extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 2. Butterfly Valves: Extended neck.
- L. Valve-End Connections:
 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 2. Solder Joint: With sockets according to ASME B16.18.
 3. Threaded: With threads according to ASME B1.20.1.

2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Hammond Valve.
 - d. Jomar.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. WATTS.
 - h. Zurn Industries, LLC.

2. Description:
 - a. Standard: MSS SP-110 or MSS-145.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Two piece, threaded.
 - d. Body Material: Bronze or Dezincification Resistant Heat Treated CW511L Brass.
 - e. Ends: Threaded, press, and soldered.
 - f. Press Ends Connections Rating: Minimum 200 psig.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Bronze or TEA coated brass.
 - j. Port: Full.

2.3 IRON, LUG TYPE BUTTERFLY VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. DeZURIK.
 - c. Flo Fab Inc.
 - d. Legend Valve & Fitting, Inc.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. WATTS.
2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - e. Seat: EPDM.
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Aluminum bronze.

2.4 BRONZE SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves.
 - b. Crane.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. WATTS.
2. Description:
 - a. Standard: MSS SP-139.

- b. CWP Rating: 200 psig(1380 kPa).
- c. Body Design: Horizontal flow.
- d. Body Material: Bronze.
- e. Ends: Threaded, press, or soldered. See valve schedule articles.
- f. Press Ends Connection Rating: Minimum 200 psig
- g. Disc: Bronze.

2.5 IRON SWING CHECK VALVES

A. Class 150, Iron Swing Check Valves with Metal Seats:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Valves.
 - b. Crane.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. Standard: MSS SP-136.
 - b. CWP Rating: 250 psig.
 - c. Body Design: Clear or full waterway.
 - d. Body Material: ASTM A 395, ductile iron with bolted bonnet.
 - e. Ends: Flanged.
 - f. Trim: Stainless steel.
 - g. Gasket: Asbestos free.

2.6 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane; Crane Energy Flow Solutions.
 - b. Hammond Valve.
 - c. Jenkins Valves; Crane Energy Flow Solutions.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Stockham; Crane Energy Flow Solutions.
 - g. WATTS.
- 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Clear or full waterway.
 - d. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - e. Ends: Flanged.
 - f. Trim: Bronze.
 - g. Gasket: Asbestos free.

- h. Closure Control: Factory-installed, exterior lever and spring.

2.7 IRON GATE VALVES

A. Class 150, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
 - b. Crane; Crane Energy Flow Solutions.
 - c. Flo Fab Inc.
 - d. Hammond Valve.
 - e. Jenkins Valves; Crane Energy Flow Solutions.
 - f. KITZ Corporation.
 - g. Legend Valve & Fitting, Inc.
 - h. Macomb Groups (The).
 - i. Milwaukee Valve Company.
 - j. NIBCO INC.
 - k. Powell Valves.
 - l. Red-White Valve Corp.
 - m. Stockham; Crane Energy Flow Solutions.
 - n. WATTS.
 - o. Zurn Industries, LLC.
2. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Material: Gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Check Valves: Install check valves for proper direction of flow.
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
- F. Install valve tags. Comply with requirements in Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
 - b. NPS 2-1/2 and Larger for Domestic Water: Iron swing check valves with, metal-seat check valves.
- B. End Connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered or press-ends.
 - 2. For Steel Piping, NPS 2 and Smaller: Threaded.
 - 3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged or threaded.
 - 4. For Steel Piping, NPS 5 and Larger: Flanged.
- C. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:

1. Ball Valves:
 - a. Two piece, full port, bronze with bronze trim.
 - b. May be provided with solder-joint ends instead of threaded ends.
2. Check Valves:
 - a. Bronze swing check valves with bronze disc, Class 125, with soldered or threaded end connections.
 - b. Bronze swing check valves with press-end connections.

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

1. Butterfly Valves:
 - a. Iron, Single-Flange Butterfly Valves: 200 CWP, NBR seat, aluminum-bronze disc.
2. Check Valves:
 - a. Iron swing check valves with metal seats, Class 150, with flanged end connections.

3.6 PUMPED SANITARY-WASTE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Ball Valves: Two piece, full port, bronze with bronze trim.
2. Bronze Swing Check Valves: Class 125, bronze disc.

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

1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
2. Iron Swing Check Valves with Closure Control: Class 125, outside lever and spring.
3. Iron Gate Valves: Class 125, NRS, flanged.
4. Lubricated Plug Valves: Class 125, cylindrical, flanged.

3.7 VALVE APPLICATIONS:

A. Domestic Water:

1. Shutoff Service: Ball and butterfly valves.
2. Throttling Service: Ball and butterfly valves.
3. Check Valves:
 - a. NPS 2(DN 50) and Smaller: Bronze swing check valves with nonmetallic disc.
 - b. NPS 2-1/2(DN 65) and Larger: Iron swing type check valves with metal seat.

B. Pumped Sanitary Waste :

1. Shutoff Service: Ball, gate, and plug valves.
2. Pump Check Valves:
 - a. NPS 2(DN 50) and Smaller: Bronze swing check valves with bronze disc.
 - b. NPS 2-1/2(DN 65) and Larger: Iron swing type check valves with outside lever and spring.

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END OF SECTION 22 0523

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SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
- B. Related Requirements:
 - 1. See Division 21 fire-suppression sections for pipe hangers for fire-suppression piping.
 - 2. Section 05 5000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for plumbing piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Width: Selected for applicable load criteria.
5. Channel Nuts: Formed or stamped steel 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.

B. Non-MFMA 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.
3. Channels: Continuous slotted steel channel with inturned lips.
4. Channel Width: Select for applicable load criteria.
5. Channel Nuts: Formed or stamped steel 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.

2.4 THERMAL-HANGER SHIELD INSERTS

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

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

2.5 FASTENER SYSTEMS

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

2.6 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand:
 - 1. Description: Single base unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Hardware: Galvanized steel or polycarbonate.
 - 4. Accessories: Protection pads.
- C. Low-Profile, Single-Base, Single-Pipe Stand:
 - 1. Description: Single base with vertical and horizontal members, and pipe support, for roof installation without membrane protection.
 - 2. Base: Single, vulcanized rubber, molded polypropylene, or polycarbonate.
 - 3. Vertical Members: Two galvanized or stainless-steel, continuous-thread, 1/2-inch rods.
 - 4. Horizontal Member: Adjustable horizontal, galvanizedstainless-steel pipe support channels.
 - 5. Pipe Supports: Roller.
 - 6. Hardware: Stainless steel.
 - 7. Accessories: Protection pads.
 - 8. Height: 12 inches above roof.
- D. High-Profile, Single-Base, Single-Pipe Stand:
 - 1. Description: Single base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Single vulcanized rubber or molded polypropylene.
 - 3. Vertical Members: Two galvanized or stainless-steel, continuous-thread, 1/2-inch rods.

4. Horizontal Member: One adjustable-height, galvanized- or stainless-steel, pipe-support slotted channel or plate.
5. Pipe Supports: Roller.
6. Hardware: Galvanized or steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread, stainless-steel rod.
8. Height: 36 inches above roof.

E. High-Profile, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: Two or more; molded polypropylene.
3. Vertical Members: Two or more, galvanized or stainless-steel channels.
4. Horizontal Members: One or more, adjustable-height, galvanized or stainless-steel pipe support.
5. Pipe Supports: Roller or Strut clamps.
6. Hardware: Galvanized or [Stainless steel.
7. Accessories: Protection pads, 1/2-inch, continuous-thread rod.
8. Height: 36 inches above roof.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 MISCELLANEOUS MATERIALS

- A. Aluminum: ASTM B 221.
- B. Carbon Steel: ASTM A 1011/A 1011M.
- C. Structural Steel: ASTM A 36/A 36M carbon-steel plates, shapes, and bars; black and galvanized.
- D. Stainless Steel: ASTM A 240/A 240M.
- E. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
- G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- 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, and at changes in direction of piping.
- L. Load Distribution: Install hangers and supports so 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 so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- N. Insulated Piping: Comply with the following:
1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 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.

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 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 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 maximum.

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. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 09 9114 "Exterior Painting." Section 09 9123 "Interior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A 780/A 780M.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use thermal-hanger shield inserts for insulated piping and tubing.
- G. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 if little or no insulation is required.
 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 6. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 7. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 8. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 9. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 10. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
- H. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- I. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
- J. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 5. C-Clamps (MSS Type 23): For structural shapes.
 6. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- L. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
- M. Comply with MSS SP-58 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- N. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- O. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
1. Use powder-actuated fasteners only in concrete construction that is suitable for their installation.
- P. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 22 0529

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SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Pipe labels.
 - 3. Stencils.
 - 4. Valve tags.

1.3 ACTION SUBMITTALS

- A. Valve Schedules: For each piping system.

1.4 COORDINATION

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

1.5 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 "Pipe Labeling Guide" for color scheme, length of field and letter height.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Black.

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

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

2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic label including flow arrow formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic label with contact-type, permanent-adhesive backing. Include flow arrow label with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service matching designations or abbreviations as used on Drawings.

2.3 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
 1. Stencil Material: Fiberboard or metal.
 2. Stencil Paint: Exterior, gloss, black enamel unless otherwise indicated. Paint may be in pressurized spray-can form.
 3. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link or beaded chain; or S-hook.

- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Provide glass front frame for each valve schedule for mounting in building mechanical room.
 - 2. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

3.3 EQUIPMENT LABEL INSTALLATION

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

3.4 PIPE LABEL INSTALLATION

- A. Pipe Label Applications: Install pipe labels as follows:
 - 1. Use pretensioned pipe labels or self-adhesive pipe labels.
- 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, on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Locate pipe labels where piping is concealed above ceilings or exposed in unfinished mechanical rooms; accessible maintenance spaces such as shafts, tunnels, and plenums as follows:
 - 1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run.
- 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 piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Install glass front frame valve schedule in building mechanical room. Locate at Owners representative approved location.

END OF SECTION 22 0553

SECTION 22 0700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulation materials for plumbing systems:
- B. Related Sections:
 - 1. Division 23 Section "HVAC Insulation."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated below. Include thermal conductivity, water-vapor permeance, thickness, and jackets (if any).
 - 1. Insulation Materials:
 - a. Mineral fiber.
 - b. Flexible elastomeric.
 - 2. Field-applied jackets.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84 by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application.
 - 1. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. K-Flex USA.
- E. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Johns Manville.
 - b. Knauf Insulation.
 - c. Manson Insulation Inc.
 - d. Owens Corning.
 - 2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
- B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. ASJ Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
- B. Vapor-Retarder Mastic: Water based; suitable for indoor use on below ambient services.
 - 1. Water-Vapor Permeance: Comply with ASTM C755, Section 7.2.2, Table 2, for insulation type and service conditions.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.
 - 1. Water-Vapor Permeance: ASTM 96, greater than 1.0 perm at manufacturer's recommended dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.

3. Color: White.

2.5 SEALANTS

A. Joint Sealants for Cellular-Glass Products:

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

B. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.
5. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Fitting Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, and mechanical joints.

C. Self-Adhesive Outdoor Jacket: Minimum 40-mil- thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with aluminum-foil facing.

1. Coordinate color of optional colors with Architect and Owner.
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Polyguard; Alumaguard.
 - b. MFM Building Products; Flex Clad 400

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Width: 3 inches.
 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.
 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.

2.9 SECUREMENTS

- A. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- B. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- O. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations:
- B. Insulation Installation at Roof Penetrations:
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation at roof structure and seal with joint sealant.
- C. Insulation Installation at Aboveground Exterior 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.
 3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 4. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 5. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
- C. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 3. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 4. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 5. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 6. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 7. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 8. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 9. 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.
 10. For mineral fiber insulation, 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.

11. For mineral fiber insulation, 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.
 12. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 13. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- D. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. 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.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
1. Flexible elastomeric pipe insulation only allowed in concealed or mechanical room locations.
- B. Insulation Installation on Roof Drain Sumps:
1. Install pipe insulation to bottom of roof drain sumps.
 2. Secure insulation to roof drain sumps and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Roof Drain Bodies:
1. Install pipe insulation to bottom of roof drain bodies exposed within building.
 2. Secure insulation to roof drain bodies and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Pipe Flanges:
1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- E. Insulation Installation on Pipe Fittings and Elbows:
1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- F. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC fitting jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturers 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.
 - 2. Fill inside of fitting jackets to prevent collapse of jacket.

3.9 FINISHES

- A. Paintable Jacket Material: Paint jacket with paint system identified in Division 09 painting Sections.
- B. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 09 9114 "Exterior Painting" and Section 09 9123 "Interior Painting."

3.10 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable pipe insulation materials and thicknesses are identified for each piping system and pipe size range.
 - 1. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Chrome-plated pipes and fittings.
 - 2. .

3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. NPS 1 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
 - 2. NPS 1-1/4 and Larger: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- B. Domestic Hot and Recirculated Hot Water:
 - 1. NPS 1 and Smaller: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - 2. NPS 1-1/4 and Larger: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.

C. Overflow Storm Water:

1. All Pipe Sizes: Vertical line up to drain body and all piping to point of building exit insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

D. Storm Water:

1. All Pipe Sizes: Vertical line up to drain body and runs within 30 Feet of drain body insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

E. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

F. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.

G. Floor Drains, Traps, and Sanitary Drain Piping within 20 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

3.12 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Pipe Fittings with Mineral Fiber Insulation:

1. PVC Fitting Covers: 20 mils thick, white.

3.13 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

1. If more than one material is listed, selection from materials listed is Contractor's option.

B. Piping:

1. Cover flexible elastomeric insulation with one of the following:
 - a. Adhere 10 x 10 woven mesh using insulation manufacturer's recommended adhesive and finish with two coats of manufacturer's recommended finish.

- b. Aluminum, Smooth or Stucco Embossed: 0.024 inch thick.
 - 2. Cover mineral fiber insulation with one of the following:
 - a. Self-adhesive outdoor jacket with aluminum foil facing.
 - b. Aluminum, Smooth or Stucco Embossed: 0.024 inch thick.
 - C. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - 1. If more than one material is listed, selection from materials listed is Contractor's option.
 - D. Piping:
 - 1. Cover flexible elastomeric insulation with one of the following:
 - a. Adhere 10 x 10 woven mesh using insulation manufacturer's recommended adhesive and finish with two coats of manufacturer's recommended finish.
 - b. Aluminum, Smooth or Stucco Embossed: 0.024 inch thick.
 - 2. Cover mineral fiber insulation with one of the following:
 - a. Self-adhesive outdoor jacket with aluminum foil facing.
 - b. Aluminum, Smooth or Stucco Embossed: 0.024 inch thick.
- 3.14 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET
 - A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 22 0700

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SECTION 22 0800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commissioning process requirements for plumbing systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning requirements.
 - 2. Division 23 Section "Commissioning of HVAC" for HVAC commissioning requirements.
 - 3. Division 26 Section "Commissioning of Electrical" for electrical commissioning requirements.

1.2 ABBREVIATIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for list of abbreviations used in the Specifications and in the Commissioning Plan.

1.3 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for list of definitions used in the Specifications and in the Commissioning Plan.

1.4 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

1.5 COMMISSIONING PROCESS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to the commissioning process.

1.6 COMMISSIONING TEAM RESPONSIBILITIES

- A. Provide information requested by the CxA for final commissioning documentation.
 - 1. Test reports
- B. Assist the CxA in all verification and functional performance tests.
- C. Refer to Division 01 Section "General Commissioning Requirements" for additional requirements pertaining to the contractor responsibilities.

1.7 SYSTEMS TO BE COMMISSIONED

- A. Any plumbing equipment or systems that are monitored and or controlled by Building Management System will be commissioned with no sampling methods.
- B. Refer to Division 01 Section "General Commissioning Requirements" for plumbing systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Refer to Division 01 Section "General Commissioning Requirements" for test equipment requirements.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Refer to Division 01 Section "General Commissioning Requirements" for meeting requirements.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. No commissioning checklists will be required to be completed by Plumbing contractor.
- B. Refer to Division 01 Section "General Commissioning Requirements" for additional participation requirements for start-up, prefucntional checklists and initial checkout.

3.3 FUNCTIONAL PERFORMANCE TESTING

- A. Sampling: No sampling of any equipment will be permitted. All equipped or types referenced in Division 01 Section "General Commissioning Requirements" will be 100% sample rate regardless of qty or size of equipment or system.
- B. Refer to Division 01 Section "General Commissioning Requirements" for additional participation requirements for functional performance testing.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.

3.5 DEFERRED TESTING

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

3.6 WRITTEN WORK PRODUCTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to written work products related to the commissioning process.

END OF SECTION 22 0800

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SECTION 22 1113 - FACILITY WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes water-distribution piping and related components outside the building for water service and fire service mains.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Detail precast concrete vault assemblies and indicate dimensions, method of field assembly, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with City of Portage standards for potable-water-service piping, including materials, installation, testing, and disinfection.
 - 2. Comply with City of Portage standards 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.

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.

1.7 PROJECT CONDITIONS

1.8 COORDINATION

- A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 Local Requirements

- A. All materials will comply with City of Portage standards for water main construction, current edition.

2.2 Pipe and Fittings

- A. Soft Copper Tube: ASTM B 88, Type K, water tube, annealed temper.
1. Copper, Solder-Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint pressure type. Furnish only wrought-copper fittings if indicated.
- B. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, CL 52 with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
- C. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end unless grooved or flanged ends are indicated.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

PART 3 - EXECUTION

3.1 CITY SPECIFICATIONS

- A. All installation and workmanship shall comply with the City of Portage standards for water main construction, current edition.

3.2 EARTHWORK

- A. Refer to Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

3.3 PIPING INSTALLATION

- A. Water-Main Connection: Arrange with utility company for tap of size and in location indicated in water main.
- B. Water-Main Connection: Tap water main according to requirements of water utility company and of size and in location indicated.
- C. Extend water-service piping and connect to water-supply source and stub-up into building with flange connection in locations and pipe sizes indicated.
 1. Terminate water-service piping within building terminate piping with flange and cap as required for piping material.

3.4 JOINT CONSTRUCTION

- A. Make pipe joints according to the following:
 1. Ductile-Iron Piping, Gasketed Joints for Water-Service Piping: AWWA C600 and AWWA M41.
 2. Dissimilar Materials Piping Joints: Use adapters compatible with both piping materials, with OD, and with system working pressure.

3.5 ANCHORAGE INSTALLATION

- A. Anchorage, General: Install water-distribution piping with restrained joints meeting City of Portage requirements.

3.6 VALVE INSTALLATION

- A. AWWA Gate Valves: Comply with AWWA C600 and AWWA M44. Install each underground valve with stem pointing up and with valve box.
- B. Corporation Valves and Curb Valves: Install each underground curb valve with head pointed up and with service box.

3.7 CONNECTIONS

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

3.8 FIELD QUALITY CONTROL

- A. 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.
- B. Hydrostatic Tests: Test at not less than 150-psig for two hours.
 - 1. Follow the testing procedure specified in the City of Portage Standard Specifications.
- C. Prepare reports of testing activities.

3.9 CLEANING

- A. Clean and disinfect water-distribution piping as follows:
 - 1. Use purging and disinfecting procedure prescribed by the City of Portage. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
- B. Prepare reports of purging and disinfecting activities.

END OF SECTION 22 1113

SECTION 22 1116 - 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. This Section includes domestic water piping inside the building.
- B. NRelated Sections include the following:
 - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and fittings.
 - 2. Division 22 Section "Domestic Water Piping Specialties" for water distribution piping specialties.

1.3 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with 125 psig, unless otherwise indicated.

1.4 INFORMATIONAL SUBMITTALS

- A. Water Samples: Specified in Part 3 "Cleaning" Article.
- B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.
- C. Comply with NSF 372, "Drinking Water System Components – Lead Content" for potable domestic water piping and components.

1.6 FIELD CONDITIONS

1.7 REGULATORY REQUIREMENTS

A. Comply with the provisions of the following:

1. Michigan Plumbing Code.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Schedule 40, galvanized. Include ends matching joining method.
 1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 2. Malleable-Iron Unions: ASME B16.39, Class 150, galvanized, hexagonal-stock body, with ball-and-socket, metal-to-metal, bronze seating surface and female threaded ends.
 3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
 4. Cast-Iron Flanges: ASME B16.1, Class 125, galvanized.
 5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.3 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: ASTM B 88, Types K, water tube, annealed 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.
- B. Hard Copper Tube: ASTM B 88, Types L, 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 ends. Furnish Class 300 flanges if required to match piping.
 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.

2.4 PEX TUBE AND FITTINGS

- A. PEX Distribution System: Crosslinked polyethylene (PEX), manufactured in accordance with ASTM F876 and ASTM F877.
 - 1. Fittings: ASTM F1960 metal cold expansion or ASTM F 1807, metal insert and crimp rings.
 - 2. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F.
 - 3. Provide pre-insulated PEX for underslab applications.

2.5 PIPING JOINING MATERIALS

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

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Standard: ASSE 1079.
 - 2. Pressure Rating: 125 psig minimum at 180 deg F.
 - 3. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 - 1. Standard: ASSE 1079.
 - 2. Factory-fabricated, bolted, companion-flange assembly.
 - 3. Pressure Rating: 125 psig minimum at 180 deg F.
 - 4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
 - 1. Nonconducting materials for field assembly of companion flanges.
 - 2. Pressure Rating: 150 psig.
 - 3. Gasket: Neoprene or phenolic.

4. Bolt Sleeves: Phenolic or polyethylene.
5. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

2.7 VALVES

- A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- B. Balancing and drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."

2.8 WATER METERS

- A. Displacement-Type Water Meters NPS 2 and Smaller: AWWA C700, nutating-disc totalization meter with bronze case and 150-psig minimum working-pressure rating; with registration in gallons or cubic feet as required by utility; and with threaded end connections.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB.
 - b. Badger Meter, Inc.
 - c. Carlon Meter Company Inc.
 - d. Invensys North American Water.
 - e. Mueller Company.
 - f. Schlumberger Limited; Water Div.
 - g. Venture Measurement.
- B. Turbine-Type Water Meters: AWWA C701, totalization meter with 150-psig minimum working-pressure rating; with registration in gallons or cubic feet as required by utility; and with the following end connections:
 1. NPS 2 and Smaller: Threaded.
 2. NPS 2-1/2 and Larger: Flanged.
 3. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB.
 - b. Badger Meter, Inc.
 - c. Hays Fluid Controls.
 - d. Invensys North American Water.
 - e. Master Meter, Inc.
 - f. McCrometer.
 - g. Mueller Company.
 - h. Schlumberger Limited; Water Div.
 - i. SeaMetrics Inc.
 - j. Venture Measurement.

- C. Compound-Type Water Meters NPS 3 and Larger: AWWA C702, totalization meter with integral main-line and bypass meters, bronze case, and 150-psig minimum working-pressure rating; with registration in gallons or cubic feet as required by utility; and with flanged end connections.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ABB.
 - b. Badger Meter, Inc.
 - c. Invensys North American Water.
 - d. Master Meter, Inc.
 - e. Mueller Company.
 - f. Schlumberger Limited; Water Div.
- D. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.
- E. Remote Registration System: Encoder-type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Comply with requirements in Section 31 2000 "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."
- C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping," and drain valves and strainers are specified in Division 22 Section "Domestic Water Piping Specialties."
 - 1. Include a backflow preventer as required by local authority having jurisdiction.
- E. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 22 1119 "Domestic Water Piping Specialties."

- G. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 22 1123 "Domestic Water Pumps."
- H. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 22 0519 "Meters and Gages for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. 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.
- C. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Brazed Joints" chapter.
- D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- E. 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.
- F. Joints for PEX Tubing: Join according to ASTM F 1807 for metal insert and copper crimp ring fittings and ASTM F 1960 for cold expansion fittings and reinforcing rings.

3.4 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.
- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 WATER METER INSTALLATION

- A. Rough-in domestic water piping for water meter connection according to utility company's requirements.
- B. Water meters will be furnished and installed by utility company.
- C. Install water meters according to AWWA M6 and utility's requirements.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger, support products, and installation in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - 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.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch.
- E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 and Smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4: 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2: 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 4: 10 feet with 1/2-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.
- G. Install vinyl-coated hangers for PEX tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1 and Smaller: 32 inches with 3/8-inch rod.
- H. Install hangers for vertical PEX tubing every 48 inches.

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping adjacent to equipment and machines, allow space for service and maintenance.
- C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

3.8 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification materials and installation in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Inspect domestic water piping as follows:
 - 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 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 final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
 - 2. Test domestic water piping as follows:
 - 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 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 to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
- B. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
- C. Prepare reports for tests and required corrective action.

3.10 ADJUSTING

- A. Perform the following adjustments before operation:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Open throttling valves to proper setting.

4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide hot-water flow in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 1. Purge new domestic water piping before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.

3.12 PIPE AND FITTING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground piping, unless otherwise indicated.
- C. Under-Building-Slab, Water-Service Piping on Service Side of Water Meter: Refer to Division 22 Section "Facility Water Distribution Piping."
- D. Under Building Slab Domestic Water Piping to Island Sinks:
 1. Pre-Insulated PEX Tube; fittings for PEX tube; and crimped or cold expansion joints. Joints below slab are not allowed.
- E. Aboveground Domestic Water Piping: Use any of the following piping materials for each size range:
 1. NPS 1/4 and Smaller for Refrigerator Final Connection: Soft copper tube, Type L; copper fittings; and soldered or compression joints.

2. NPS 1 and Smaller Branch piping serving individual fixtures: PEX Tube; fittings for PEX tube; and crimped or cold expansion joints. Concealed joints are not allowed.
 3. NPS 1 and Smaller: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 4. NPS 1-1/4 and NPS 1-1/2: Hard copper tube, Type L; soldered joints.
 5. NPS 2: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 6. NPS 2-1/2 : Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 7. NPS 3: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 8. NPS 4: Hard copper tube, Type L; copper pressure fittings; and soldered joints.
- F. At Installer's option for aboveground domestic water piping, install Type L, drawn copper tube with mechanical joint copper press fittings for pipe sizes 4 inches and smaller.
1. Valves with bodies meeting requirements of Section "General Duty valves for Plumbing Piping" may be used in mechanical joint copper press systems

3.13 VALVE SCHEDULE

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Shutoff Duty: Use bronze ball valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
 2. Throttling Duty: Use bronze ball valves for piping NPS 2 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 and larger.
 3. Hot-Water-Piping, Balancing Duty: Calibrated balancing valves.
 4. Drain Duty: Hose-end drain valves.
- B. Cast-iron, grooved-end valves may be used with grooved-end piping.
- C. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, on each water supply to plumbing fixtures that do not have supply stops and on each water supply to plumbing fixtures that do have supply stops but where take off from main or branch is not in the same room.
- D. Use check valves to maintain correct direction of domestic water flow to and from equipment.
- E. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
1. Install hose-end drain valves at low points in water mains, risers, and branches.
- F. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Division 22 Section "Domestic Water Piping Specialties."

END OF SECTION 22 1116

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 HYPERLINK

"<http://contact.arcomnet.com/ContentContact.aspx?sect=221119&ver=09/01/17&format=FL&sid=13860>"
RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following domestic water piping specialties:

1. Backflow preventers.
2. Calibrated balancing valves.
3. Temperature-actuated water mixing valves.
4. Strainers.
5. Outlet boxes.
6. Hose bibbs.
7. Wall hydrants.
8. Drain valves.
9. Water hammer arresters.

- B. Related Sections include the following:

1. Division 22 Section "Meters and Gages for Plumbing Piping" for flow meters, thermometers and pressure gages in domestic water piping.
2. Division 22 Section "Sanitary Waste Piping Specialties" for trap seal protection device.
3. Division 22 Section "Domestic Water Piping" for water meters.

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig, unless otherwise indicated.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.
- B. Backflow preventer assembly test reports.

1.7 QUALITY ASSURANCE

- A. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61.
- B. Comply with NSF 372 for low lead.

2.2 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. FEBCO; SPX Valves & Controls.
 - d. Watts Industries, Inc.; Water Products Div.
 - e. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1013.
 - 3. Operation: Continuous-pressure applications.
 - 4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
 - 5. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and larger.
 - 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 - 7. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
- B. Double-Check, Detector-Assembly Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames Co.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; SPX Valves & Controls.
 - d. Watts Industries, Inc.; Water Products Div.
 - e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1048 and FMG approved or UL listed.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
5. Body: Cast iron with interior lining complying with AWWA C550 or that is FDA approved.
6. End Connections: Flanged.
7. Accessories:
 - a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.
 - b. Bypass: With displacement-type water meter, shutoff valves, and reduced-pressure backflow preventer.

2.3 CALIBRATED BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett.
 - b. Taco, Inc.
 - c. Armstrong International, Inc.
 - d. Tour Andersson.
 - e. Apollo Valves.
 - f. Watts Industries, Inc.; Water Products Div.
2. Type: Ball valve with two readout ports and memory setting indicator.
3. Body: Bronze.
4. Size: Same as connected piping, but not larger than NPS 2.

2.4 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Primary, Thermostatic, Water Mixing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Apollo/Conbraco Industries, Inc.
 - b. Armstrong International, Inc.
 - c. Lawler Manufacturing Company, Inc.
 - d. Leonard Valve Company.
 - e. Powers; a Watts Industries Co.
 - f. Symmons Industries, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig.
4. Type: Exposed-mounting, thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.

6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, dial thermometer, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
9. Valve Finish: Rough bronze.
10. Piping Finish: Copper.

B. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Controls.
 - b. Cash Acme.
 - c. Apollo/Conbraco Industries, Inc.
 - d. Honeywell Water Controls.
 - e. Lawler Manufacturing Company, Inc.
 - f. Leonard Valve Company.
 - g. Powers; a Watts Industries Co.
 - h. Watts Industries, Inc.; Water Products Div.
 - i. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1070, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig minimum, unless otherwise indicated.
4. Body: Bronze or brass body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded with integral check valves.
7. Finish: Rough or chrome-plated bronze.
8. Tempered-Water Setting: 110 deg F.

2.5 EXPANSION TANKS

- A. For water heater domestic hot water system, provide bladder type expansion tank of size and capacity as indicated, with precharged air cushion, heavy duty rubber bladder, charging valve, and rust resistant finish. Watts or equivalent.
- B. For heat exchanger domestic hot water systems, provide diaphragm type vertical ASME rated steel expansion tank of size and capacity as indicated, with precharged air cushion, heavy duty rubber diaphragm, charging valve, and rust resistant finish. Amtrol or equivalent.

2.6 STRAINERS FOR DOMESTIC WATER PIPING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Ames.
 2. Apollo.
 3. Watts.
 4. Mueller
 5. Wilkins.
- B. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2(DN 65) and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.020 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
 - c. Strainers NPS 5 and Larger: 0.10 inch.
6. Drain: Pipe plug for NPS 2 and smaller; Factory-installed, hose-end drain valve for NPS 2-1/2 and larger.

2.7 OUTLET BOXES

A. Ice Maker Outlet Boxes:

1. Mounting: Recessed.
2. Material and Finish: Enameled-steel or epoxy-painted-steel or plastic box and faceplate.
3. Supply Shutoff Fittings: NPS 1/4 quarter turn ball valve, chrome plated.

B. Clothes Washer Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company.
 - b. Guy Gray Manufacturing Co., Inc.
 - c. IPS Corporation.
 - d. LSP Products Group, Inc.
 - e. Oatey.
 - f. Plastic Oddities; a division of Diverse Corporate Technologies
 - g. Sioux Chief Manufacturing Company, Inc
2. Mounting: Recessed.
3. Material and Finish: Stainless-steel box and faceplate.
4. Faucet: Separate hot- and cold-water, valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
5. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
6. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.

2.8 HOSE BIBBS

A. Close Coupled Wall Hydrant (Hose Bibb):

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

- f. Woodford Manufacturing Company.
 - g. Zurn Plumbing Products Group.
 - 2. Basis of Design: Woodford B75.
 - 3. Pressure Rating: 125 psig.
 - 4. Operation: Loose key.
 - 5. Inlet: NPS 3/4 .
 - 6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
 - 7. Box: Slim, flush mounting with cover.
 - 8. Box and Cover Finish: Chrome plated
 - 9. Operating Keys(s): One with each wall hydrant.
- B. Hose Bibbs:
- 1. Standard: ASME A112.18.1 for sediment faucets.
 - 2. Body Material: Bronze.
 - 3. Seat: Bronze, replaceable.
 - 4. Supply Connections: NPS 1/2 or NPS 3/4 threaded or solder-joint inlet.
 - 5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
 - 6. Pressure Rating: 125 psig.
 - 7. Vacuum Breaker: Integral nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
 - 8. Finish for Equipment Rooms: chrome or nickel plated.
 - 9. Finish for Service Areas: Chrome or nickel plated.
 - 10. Finish for Finished Rooms: Chrome or nickel plated.
 - 11. Operation for Equipment Rooms: Wheel handle or operating key.
 - 12. Operation for Service Areas: Operating key.
 - 13. Operation for Finished Rooms: Operating key.
 - 14. Include operating key with each operating-key hose bibb.
 - 15. Include wall flange with each chrome- or nickel-plated hose bibb.

2.9 WALL HYDRANTS

- A. Nonfreeze Wall Hydrants (NFWH):
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Woodford Manufacturing Company.
 - g. Zurn Plumbing Products Group.
 - 2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
 - 3. Pressure Rating: 125 psig.
 - 4. Operation: Loose key.
 - 5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
 - 6. Inlet: NPS 3/4 or NPS 1.

7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
11. Nozzle and Wall-Plate Finish: Polished nickel bronze.
12. Operating Keys: Two with each wall hydrant.

2.10 DRAIN VALVES

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

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

B. Gate-Valve-Type, Hose-End Drain Valves:

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4.
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.12

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 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 not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
 - 4. Register each backflow preventer with the local jurisdiction for ongoing testing.
- C. Install calibrated balancing valves in locations where they can easily be adjusted.
- D. Install primary temperature-actuated water mixing valves in accordance with manufacturer's requirements, and with shutoff valves on inlets and with shutoff valve on outlet.
- E. Install Y-pattern strainers for water on supply side of each inline pump and elsewhere as indicated.
- F. Outlet Boxes: Install boxes recessed in wall or surface mounted on wall. Install 2-by-4-inch fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 06 1000 "Rough Carpentry."
- G. Install water hammer arresters in water piping according to PDI-WH 201.
- H. Install hose bibs with vacuum breaker on wall.
- I. Install nonfreeze wall hydrants with valve body within building, not within outside wall.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

3.3 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:

1. Test each backflow preventer according to authorities having jurisdiction and the device's reference standard.
 2. Test each domestic water piping specialty according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.4 ADJUSTING

- A. Set field-adjustable flow set points of calibrated balancing valves.
- B. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION 22 1119

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SECTION 22 1123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic water circulation:

1.3

- 1. Wet rotor circulator with ECM

- B. Terminology used in this Section is from HI 1.1-1.2 and HI 5.1-5.6.

1.4 DEFINITIONS

- A. 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.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include materials of construction, rated capacities, certified performance curves with operating points plotted on curves, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Sustainable Design Submittals:

- 1. <Double click to insert sustainable design text for pump controls.>

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.
- D. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.8 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers:
 - 1. Bell & Gossett.
 - 2. Armstrong Pumps Inc.
- B. Basis of Design: Bell & Gossett Model NRF.
- C. Description: Factory-assembled and -tested in-line horizontal system lubricated centrifugal pumps.
 - 1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
 - 2. Casing: Lead-free bronze, with companion-flange connections.
 - 3. Motor Bearings: Carbon.
 - 4. Face Plate: Stainless steel.
 - 5. Impeller: Corrosion-resistant material.
 - 6. Shaft: Ceramic.

7. Motor: Multi-speed. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

2.3 WET ROTOR INLINE PUMPS

A. Manufacturers:

1. Bell & Gossett.

B. Basis of Design: Bell & Gossett Model ecocirc XL.

C. Description: Factory-assembled and -tested, wet rotor in-line pumps with ECM motor and integrated variable frequency drive.

1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
2. Casing: Lead-free bronze, with companion-flange connections.
3. Impeller: Plastic or stainless steel.
4. Shaft: Stainless steel.
5. Rotor: Permanent magnet.
6. Bearing: Carbon sleeve.
7. Gasket/O-Ring: EPDM.
8. All Other Wetted Parts: Stainless steel.
9. Motor Type: Electronically commutated motor /permanent magnet and includes:
 - a. Class F motor insulation.
 - b. Integrated motor protection against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
10. Integrated Variable Frequency Drive: Tested as one unit by the manufacturer and includes:
 - a. MODBUS or BACnet connections built into the VFD as standard.
 - b. Analog inputs, such as 0-10V and 4-20mA inputs built into the VFD.
11. Maximum Working Pressure: 175 psi.
12. Maximum Working Temperature: 230°F.

2.4 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 0500 "Common Motor Requirements for Plumbing Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.5 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Manufacturers:

- a. Honeywell International, Inc.
 - b. Square D.
 - c. White-Rodgers Div.; Emerson Electric Co.
2. Type: Strap-on sensor for installation on hot-water circulation piping.
 3. Operation of Pump: On or off.
 4. Power Requirement: 120 V, ac.
 5. Settings: Start pump at 100 deg F and stop pump at 120 deg F.

2.6 FLEXIBLE CONNECTORS

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.
- C. Install horizontally mounted, in-line, centrifugal pumps with shaft(s) horizontal.
- D. Install vertically mounted, in-line, close-coupled centrifugal pumps with shaft vertical.
- E. Pump Mounting: Install vertically mounted, in-line, close-coupled centrifugal pumps with cast-iron base mounted on concrete base using elastomeric pads. Comply with requirements for concrete base specified in Section 03 3000 "Cast-in-Place Concrete."
 1. Minimum Deflection: 1/4 inch.
 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 5. Install anchor bolts to elevations required for proper attachment to supported equipment.
- F. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of size required to support pump weight.
 1. Comply with requirements for hangers and supports specified in Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."

3.3 CONTROL INSTALLATION

- A. Install electric-type thermostats on hot-water return piping.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section "Domestic Water Piping."
 - 1. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section "Domestic Water Piping Specialties" for strainers.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- F. Connect thermostats to pumps that they control.

3.5 IDENTIFICATION

- A. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment" for identification of pumps.

3.6 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set thermostats for automatic starting and stopping operation of pumps.
 - 5. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 7. Start motor.
 - 8. Open discharge valve slowly.
 - 9. Adjust temperature settings on thermostats.

10. .

3.7 ADJUSTING

- A. Adjust domestic water pumps to function smoothly, and lubricate as recommended by manufacturer.
- B. Adjust initial temperature set points.
- C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

END OF SECTION 22 1123

SECTION 22 1313 - FACILITY SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes gravity-flow, nonpressure sanitary sewerage outside the building, with the following components:
 - 1. Cleanouts.
 - 2. Precast concrete manholes.

1.2 PERFORMANCE REQUIREMENTS

- A. Gravity-Flow, Nonpressure, Drainage-Piping Pressure Rating: 10-foot head of water.

1.3 ACTION SUBMITTALS

- A. Shop Drawings:
 - 1. Manholes. Include plans, elevations, sections, details, and frames and covers.

1.4 INFORMATION SUBMITTALS

- A. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.
- B. Field quality-control test reports.

1.5 DELIVERY CONDITIONS

- A. Do not store pipe and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.
- C. Handle manholes according to manufacturer's written rigging instructions.

1.6 PROJECT CONDITIONS

1.7 QUALITY ASSURANCE

- A. Regulatory Requirements:
 - 1. Comply with City of Portage standards for sanitary service piping, including materials, installation, and testing.

PART 2 - PRODUCTS

2.1 LOCAL REQUIREMENTS

- A. All materials will comply with City of Portage standards for sanitary construction, current edition.

2.2 PVC PIPE AND FITTINGS

- A. PVC Sewer Pipe and Fittings, NPS 15 and Smaller: ASTM D 3034, SDR 26, with bell-and-spigot ends for gasketed joints with ASTM F 477, elastomeric seals.

2.3 NONPRESSURE-TYPE PIPE 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 corrosion-resistant metal tension band and tightening mechanism on each end.]
 - 1. Sleeve Materials:
 - a. For Concrete Pipes: ASTM C443, rubber
 - b. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - c. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926 PVC
 - d. For Dissimilar Pipes: ASTM 5926, PVC or other material compatible with materials being joined.
- B. Shielded, Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
- C. Ring-Type, Flexible Couplings: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.4 CLEANOUTS

- A. Description: Cast-iron cleanout with threaded adjustable housing, flanged ferrule, brass cleanout plug, and round cast-iron heavy-duty, secured, scoriated cover. Wade Model 6000Z-75-179 or equivalent.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB Manufacturing Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Wade Div.; Tyler Pipe.
 - e. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
 - 2. Top-Loading Classification: Medium duty.
 - 3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

2.5 MANHOLES

- A. Standard Precast Concrete Manholes: ASTM C 478 , precast, reinforced concrete, of depth indicated, with provision for sealant joints.
1. Diameter: 48 inches minimum, unless otherwise indicated.
 2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
 3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section and having separate base slab or base section with integral floor.
 4. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
 5. Top Section: Eccentric-cone type, unless flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
 7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
 8. Steps: Individual FRP steps, or ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches .
 9. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover.
 10. Manhole Frames and Covers: Ferrous; 24-inch ID by 7- to 9-inch riser with 4-inch- minimum width flange and 26-inch- diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
 - a. Material: ASTM A 536, Grade 60-40-18 ductile iron, unless otherwise indicated.

2.6 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318/318R, ACI 350R, and the following:
1. Cement: ASTM C 150, Type II.
 2. Fine Aggregate: ASTM C 33, sand.
 3. Coarse Aggregate: ASTM C 33, crushed gravel.
 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - a. Invert Slope: 1 percent through manhole.

2. Benches: Concrete, sloped to drain into channel.
 - a. Slope: 4 percent.
- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water/cementitious materials ratio.
 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

PART 3 - EXECUTION

3.1 CITY SPECIFICATIONS

- A. All installation and workmanship shall comply with the City of Portage standards for sanitary sewer construction, current edition.

3.2 EARTHWORK

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

3.3 PIPING APPLICATIONS

- A. Pipe couplings and fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
 1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping, unless otherwise indicated.
 - a. Shielded flexible couplings for same or minor difference OD Pipes.

3.4 PIPING INSTALLATION

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

1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
2. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.

F. 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.

3.5 PIPE JOINT CONSTRUCTION

- A. Basic piping joint construction is specified in Division 22 Section "Common Work Results for Plumbing" Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
- B. Join gravity-flow, nonpressure, drainage piping according to the following:
1. 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.
 2. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-gasket joints.
 3. Join dissimilar pipe materials with nonpressure-type, flexible couplings.

3.6 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C 891.
- C. Form continuous concrete channels and benches between inlets and outlet.
- D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.7 CONCRETE PLACEMENT

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

3.8 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
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, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.

- C. Set cleanout frames and covers in concrete pavement with tops flush with pavement surface.

3.9 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Division 22 "Sanitary Waste and Vent Piping."

3.10 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
 - 1. Use detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.11 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 95 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.
 - e. Exfiltration: Water leakage from or around piping.
 - 3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
 - 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Complete mandrel test on all flexible piping installations.
 - 3. Schedule tests and inspections at least 24 hours' advance notice.
 - 4. Submit separate report for each test.
 - 5. Hydrostatic Tests: Only if specifically requested by Construction Manager. Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
 - a. Allowable leakage is maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
 - 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. Air Tests: Only if specifically requested by Construction Manager. Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
 - a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
 - b. Option: Test concrete gravity sewer piping according to ASTM C 924.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

3.12 CLEANING

- A. Clean interior of piping of dirt and superfluous material. Flush with potable water.

END OF SECTION 22 1313

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SECTION 22 1316 - 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. This Section includes soil and waste, sanitary drainage and vent piping inside the building.
- B. This Section includes soil and waste, sanitary drainage and vent piping inside the building and to a point five feet outside the building.
- C. This Section includes forced main waste piping inside the building.
- D. The following Sections contain related requirements:
 - 1. Division 22 Section "General Duty Valves for Plumbing Piping" for valves in forced main piping.
 - 2. Division 22 Section "Sanitary Waste Piping Specialties" for soil, waste, and vent piping system specialties.
 - 3. Division 22 Section "Sanitary Sewerage Pumps" for sewage sump pumps.
 - 4. Division 22 Section "Wastewater Sump Pumps" for elevator sump pumps.

1.3 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. Forced Main Waste Piping: 50 psig.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

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

1.7 REGULATORY REQUIREMENTS

A. Comply with the provisions of the following:

1. Michigan Plumbing Code.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

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

C. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.

1. Gaskets: ASTM C 564, rubber.
2. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

D. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 and CISPI 301.

1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.

E. Steel Pipe: ASTM A 53/A 53M, Type E, Schedule 40, galvanized. Include ends matching joining method.

1. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.
 - a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Pressure Fittings:
 - a. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - b. Malleable-Iron Unions: ASME B16.39; Class 150, galvanized, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - c. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
 - d. Cast-Iron Flanges: ASME B16.1, Class 125, galvanized.
 - e. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

F. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.

1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

G. Adhesive Primer: ASTM F656.

H. Solvent Cement: ASTM D2564.

2.2 ELEVATOR SUMP FORCED MAIN VALVES

A. PVC Non-Union Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Georg Fischer LLC; GF Piping Systems.
 - b. IPEX.
 - c. Jomar International.
 - d. NIBCO Inc.
 - e. Spears Manufacturing Company.
 - f. Thermoplastic Valves Inc.
2. Description:
 - a. Standard: MSS SP-122.
 - b. Pressure Rating and Temperature: 125 psig at 73 deg F.
 - c. Body Material: PVC.
 - d. Body Design: Non-union type.
 - e. End Connections: Socket or threaded.
 - f. Ball: PVC; full port.
 - g. Seals: PTFE or EPDM-rubber O-rings suitable for application.
 - h. Handle: Tee shaped.

B. PVC Ball Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Georg Fischer LLC; GF Piping Systems.
 - b. IPEX.
 - c. NIBCO Inc.
 - d. Spears Manufacturing Company.
 - e. Thermoplastic Valves Inc.
2. Description:
 - a. Pressure Rating and Temperature: 125 psig at 73 deg F.
 - b. Body Material: PVC.
 - c. Body Design: Union-type ball check.
 - d. End Connections for Valves NPS 2 and Smaller: Detachable, socket or threaded.
 - e. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, socket or threaded.
 - f. End Connections for Valves NPS 2-1/2 to NPS 4: Detachable, flanged.
 - g. Ball: PVC.
 - h. Seals: EPDM- or FKM-rubber O-rings suitable for application.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 1. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
- 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. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."
- E. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- F. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- G. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."
- H. 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."
- 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 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
 - 1. Below slab sanitary drains shall be minimum 3-inch (76-mm) unless otherwise indicated with reducer down to above slab pipe size located at floor line.
- K. Install soil and waste drainage and vent piping at the minimum slopes required by plumbing code.
- L. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- M. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- N. Install underground PVC soil and waste drainage piping according to ASTM D 2321.

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

3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Gasketed Joints: Make with rubber gasket matching class of pipe and fittings.
 - 2. Hubless Joints: Make with rubber gasket and sleeve or clamp.
- C. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
 - 1. For indoor applications, use PVC primer that has a VOC content of 550 g/L or less.
- D. PVC Pressure Piping Joints: Join piping according to ASTM D 2855.
- E. 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.

3.4 VALVE INSTALLATION

- A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing."
- B. Shutoff Valves: Install shutoff valve on each pump discharge.
 - 1. Use gate or full-port ball valve for piping NPS 2 and smaller.
 - 2. Use gate valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing check valve, downstream from shutoff valve, on each pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
 - 2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
 - 3. Install backwater valves in accessible locations.
 - 4. Backwater valves are specified in Division 22 Section "Domestic Water Piping Specialties."

3.5 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 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.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6: 60 inches with 3/4-inch rod.
 5. NPS 8 to NPS 10: 60 inches with 7/8-inch rod.
 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 3. NPS 2: 10 feet with 3/8-inch rod.
 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 5. NPS 3: 12 feet with 1/2-inch rod.
 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 7. NPS 6: 12 feet with 3/4-inch rod.
- H. Install supports for vertical steel piping every 15 feet.
- I. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.
 2. NPS 3: 48 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
 4. NPS 6: 48 inches with 3/4-inch rod.
 5. NPS 8 to NPS 10: 48 inches with 7/8-inch rod.
- J. Install supports for vertical PVC piping every 48 inches.

3.6 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code. Refer to other Division 22 plumbing fixtures sections.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section "Sanitary Waste Piping Specialties."
 - 4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
 - 5. Comply with requirements for cleanouts and drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
 - 6. Comply with requirements for backwater valves cleanouts and drains specified in Section 22 1319 "Sanitary Waste Piping Specialties."
 - 7. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.
- D. Connect force-main piping to the following:
 - 1. Sewage Pump: To sewage pump discharge.

3.7 IDENTIFICATION

- A. Identify exposed sanitary waste and vent piping.
- B. Comply with requirements for identification specified in Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

- D. Test sanitary waste and vent piping 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 waste and vent piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 3. Roughing-in Plumbing Test Procedure: Test waste and vent piping except outside leaders on completion of roughing-in.
 - a. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water.
 - b. From 15 minutes before inspection starts to completion of inspection, water level must not drop.
 - c. Inspect joints for leaks.
 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight.
 - a. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg.
 - b. Use U-tube or manometer inserted in trap of water closet to measure this pressure.
 - c. Air pressure must remain constant without introducing additional air throughout period of inspection.
 - d. Inspect plumbing fixture connections for gas and water leaks.
 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 6. Prepare reports for tests and required corrective action.
- E. 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.
 - b. 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.

3.9 CLEANING AND PROTECTION

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect sanitary waste and vent piping during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.
- D. 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.

3.10 PIPING SCHEDULE

- A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground, soil, waste, and vent piping NPS 1 1/2(DN 40) and smaller shall be any of the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
- C. Aboveground, soil, waste, and vent piping NPS 2(DN 50) through NPS 10(DN 250) shall be any of the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 - 2. PVC pipe, PVC socket fittings, and solvent-cemented joints.
 - a. PVC above ground only allowed in concealed locations.
- D. Underground, soil, waste, and vent piping NPS 10(DN 250) and smaller shall be any of the following:
 - 1. PVC pipe, PVC socket fittings, and solvent-cemented joints.
- E. Aboveground forced main piping shall be the following:
 - 1. PVC solid wall pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 22 1316

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SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Cleanouts.
 - 2. Floor drains.
 - 3. Trap-seal protection devices.
 - 4. Grease interceptors.
 - 5. Solids interceptors
- B. Related Requirements:
 - 1. Section 22 1423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene.
- B. FOG: Fats, oils, and greases.
- C. PVC: Polyvinyl chloride.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Include rated capacities, operating characteristics, and accessories for grease interceptors.

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Drainage 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.

PART 2 - PRODUCTS

2.1 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. WATTS.
 - f. Zurn Industries, LLC.
- 2. Standard: ASME A112.14.1.
- 3. Size: Same as connected piping.
- 4. Body: Cast iron.
- 5. Cover: Cast iron with bolted or threaded access check valve.
- 6. End Connections: Hubless.
- 7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
- 8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain-Outlet Backwater Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. WATTS.
 - f. Zurn Industries, LLC.
- 2. Size: Same as floor drain outlet.
- 3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
- 4. Check Valve: Removable float.

2.2 CLEANOUTS

A. Exposed End of Pipe Cast-Iron Cleanouts:

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

- a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Sioux Chief Mfg. Co.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Div.
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
 3. Size: Same as connected drainage piping
 4. Body Material: Hubless, cast-iron soil pipe as required to match connected piping.
 5. Closure: Countersunk, brass plug.
 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Div.
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Light Commercial Operation.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
6. Outlet Connection: Spigot.
7. Closure: Brass plug with straight threads and gasket.
8. Adjustable Housing Material: Cast iron with threads.
9. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
10. Frame and Cover Type:
 - a. Ceramic, Mosaic & Quarry Tile Floors: Terrazzo top type with square nickel bronze top.
 - b. Asphalt & Vinyl Tile Floors: Tile top type with square nickel bronze top.
 - c. Terrazzo Floors: Terrazzo top type with round nickel bronze top.
 - d. Carpet Floors: Carpet marker type with round nickel bronze top.
 - e. Other Finished Floors: Heavy duty type with round nickel bronze top.
 - f. Unfinished Concrete Floors: Heavy duty type with round cast iron top.

C. Cast-Iron Interior Finished Wall Cleanouts:

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

3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, stainless-steel cover plate with screw.

D. Cast-Iron Interior Unfinished Accessible Area Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, drilled-and-threaded brass plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.3 FLOOR DRAINS

A. Cast-Iron Floor Drains - General:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - d. Tyler Pipe; Wade Div.
 - e. Watts Drainage Products Inc.
 - f. Zurn Plumbing Products Group; Light Commercial Operation.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3.

B. Cast Iron Floor Drains: Coated gray iron body having integral double drainage flange with weep holes and no-hub spigot or push-on bottom outlet. Provide flashing clamp device where located in membrane floor or when flashing is required for pans. Floor drain type designations and sizes are indicated on Drawings and scheduled below:

1. FD-1: Toilet rooms and finished areas not specifically noted, "Wade" 1100G6 or equivalent with 6 inch (150 mm) square nickel bronze adjustable top.
2. FD-2: Mechanical room, receiving and storage room, "Wade" 1310TD or equivalent with 9 inch round ductile iron top, sediment bucket.
3. FD-3: Mechanical Room Floor sink, "Wade" 9110 8" x 8" x 6" or equivalent with removable cast iron grate, cast iron body, aluminum dome strainer at outlet.
4. FD-4: Single shower drain, "Wade" 1100-STD5-1 or equivalent with 5 inch round nickel bronze adjustable top.

5. FD-5: Kitchen floor sink, "Wade" 9140 12" x 12" x 8" or equivalent with cast iron body, A.R.E. interior, aluminum dome strainer at outlet, 1/2 grate.

2.4 TRAP SEAL PROTECTION DEVICES

A. Barrier Type Trap Seal Protection Devices:

1. Subject to compliance with requirements, provide SureSeal Manufacturing Inline Floor Drain Trap Sealer, MIFAB MI-GARD Trap Seal, or Jay R. Smith Model 2692 Trap Seal.
2. Standard: ASSE 1072.
3. Size: 2 inch thru 4 inch as required

2.5 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

2.6 GREASE INTERCEPTORS (GI-1)

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

1. Plastic:
 - a. Green Turtle (USA).
 - b. Schier Products Company. (GB-75 Located exterior of the building)

B. Description:

1. Descriptive Type or Function: Factory-fabricated interceptor for separating and removing oil from food-preparation wastewater in accordance with State of Michigan code requirements.
2. Standard: ASME A112.14.3 and PDI-G101.
3. Rated for 75 gpm, 125 Gal liquid Capacity, 861 gal grease, 31 gal solid, 4" inlet/outlet, 47"x33"x40", 190 LBS.
4. Body Material: Plastic.
5. Top Mounting: Flushwith grade. Include extension as required by field conditions. Cast Iron Cover H-20 Rated.
6. Flow-Control Fitting: Integral or field installed.
7. Provide Anti-Flotation Anchor Kit

2.7 SOLIDS INTERCEPTORS

A. Solids Interceptors:

1. Plastic Solids Interceptors: (SI-1)
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Striem Sidekick.
2. Type: Factory-fabricated interceptor made for removing and retaining art room sediment from wastewater.
3. Body Material: plastic.
4. Interior Separation Device: Polycarbonate, 1/8" perforation, .17 gal solids capacity, silicone o-ring.

5. Body Dimensions: Suitable for mounting under sink with sufficient space for removing basket through the top.
6. Maximum Flow Rate: 23 gpm.
7. Inlet and Outlet Size: 1-1/2 inch(38 mm) Multi directional.
8. Provide extra o-ring replacement kit for each o-ring on the unit.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 1. Install wall cleanouts in all finished spaces.
 2. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 3. Locate at each change in direction of piping greater than 45 degrees.
 4. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 5. Locate at base of each vertical soil and waste stack.
 6. For cleanouts at grade within 5'-0" of building install cleanouts and extension from drain pipe to cleanout at grade where indicated. Set cleanout in poured concrete block 18 inches by 18 inches by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade or flush with grade when installed in paving.
 7. Align square tops parallel with building walls.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
 5. Align square tops parallel with floor tile.
- F. Install trap-seal protection devices at floor sink and floor drain outlets (omit at shower floor drains) during trim out stage of project.
- G. Install grease interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.
2. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

H. Install kitchen grease interceptor as indicated, as required by the plumbing code and health department.

I. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

J. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

3.3 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

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

3.4 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain grease interceptors.

END OF SECTION 22 1319

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SECTION 22 1413 - FACILITY STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes storm drainage piping inside the building and to a point five feet outside the building.
- B. Related Sections include the following:
 - 1. Division 22 Section "Storm Drainage Piping Specialties" for storm drainage piping system specialties.

1.3 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.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

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

1.7 REGULATORY REQUIREMENTS

- A. Comply with the provisions of the following:
 - 1. Michigan Plumbing Code.

1.8 FIELD CONDITIONS

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, fitting, and joining materials.
- B. Hub-and-Spigot, Cast-Iron Pipe and Fittings: ASTM A 74, Service class.
 - 1. Gaskets: ASTM C 564, rubber.
 - 2. Caulking Materials: ASTM B 29, pure lead and oakum or hemp fiber.
- C. Hubless Cast-Iron Pipe and Fittings: ASTM A 888 and CISPI 301.
 - 1. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - a. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
- D. Solid-Wall PVC Pipe: ASTM D 2665, solid-wall drain, waste, and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.
- E. Adhesive Primer: ASTM F 656.
- F. Solvent Cement: ASTM D 2564.

PART 3 - EXECUTION

3.1 EARTH MOVING

- A. Comply with requirements for excavating, trenching, and backfilling specified in Section 31 2000 "Earth Moving."

3.2 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section "Storm Drainage Piping Specialties."
- C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation

watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

- D. 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."
- E. Make changes in direction for storm piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- F. Lay buried building drain piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- G. Install storm drainage piping at the minimum slopes required by plumbing code.
- H. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- I. Install above slab PVC storm drainage piping according to ASTM D 2665.
- J. Install underground PVC storm drainage piping according to ASTM D 2321.
- K. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.3 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Hub-and-Spigot, Cast-Iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- C. Hubless Cast-Iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
- D. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
 - 1. For indoor applications, use PVC primer that has a VOC content of 550 g/L or less.

3.4 SPECIALTY PIPE FITTING INSTALLATION

3.5 VALVE INSTALLATION

- A. General-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

- B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
 - 1. Use gate or full-port ball valve for piping NPS 2 and smaller.
 - 2. Use gate valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing check valve, downstream from shutoff valve, on each sewage pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
 - 2. Install backwater valves in accessible locations.
 - 3. Backwater valve are specified in Division 22 Section "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - 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.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
 - 2. NPS 3: 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 - 4. NPS 6: 60 inches with 3/4-inch rod.
 - 5. NPS 8 to NPS 10: 60 inches with 7/8-inch rod.
 - 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- F. Install supports for vertical cast-iron soil piping every 15 feet.
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2: 48 inches with 3/8-inch rod.

2. NPS 3: 48 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 48 inches with 5/8-inch rod.
4. NPS 6: 48 inches with 3/4-inch rod.
5. NPS 8 to NPS 10: 48 inches with 7/8-inch rod.

H. Install supports for vertical PVC piping every 48 inches.

I. Support piping and tubing not listed above according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

- A. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.
- B. Connect storm drainage piping to roof drains and storm drainage specialties.

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 48 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction.
 1. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 2. Prepare reports for tests and required corrective action.

3.9 CLEANING

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

3.10 PIPING SCHEDULE

- A. Aboveground storm drainage piping NPS 2(DN 50) through NPS 10(DN 250) shall be any of the following:
 - 1. Hubless cast-iron soil pipe and fittings; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
 - 2. PVC pipe, PVC socket fittings, and solvent-cemented joints.
 - a. PVC above ground only allowed in concealed locations.
- B. Underground storm drainage piping NPS 10(DN 250) and smaller shall be any of the following:
 - 1. PVC pipe, PVC socket fittings, and solvent-cemented joints.

END OF SECTION 22 1413

SECTION 22 1423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following storm drainage piping specialties:
 - 1. Cleanouts.
 - 2. Roof drains.
- B. Related Requirements:
 - 1. Section 07 6200 "Sheet Metal Flashing and Trim" for penetrations of roofs.
 - 2. Section 07 8413 "Penetration Firestopping" for firestopping roof penetrations.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 CLEANOUTS

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

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

C. Cast-Iron Floor Cleanouts:

1. Standard: ASME A112.36.2M for adjustable housing cleanout.
2. Size: Same as connected branch.
3. Type: Adjustable housing.
4. Body or Ferrule: Cast iron.
5. Outlet Connection: Spigot.
6. Closure: Brass plug with straight threads and gasket.
7. Adjustable Housing Material: Cast iron with threads.
8. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
9. Frame and Cover Type:
 - a. Ceramic, Mosaic & Quarry Tile Floors: Terrazzo top type with square nickel bronze top.
 - b. Asphalt & Vinyl Tile Floors: Tile top type with square nickel bronze top.
 - c. Terrazzo Floors: Terrazzo top type with round nickel bronze top.
 - d. Carpet Floors: Carpet flange type with round nickel bronze top.
 - e. Other Finished Floors: Heavy duty type with round nickel bronze top.
 - f. Unfinished Concrete Floors: Heavy duty type with round cast iron top.

D. Cast-Iron Interior Finished Wall Cleanouts:

1. Standard: ASME A112.36.2M. Include wall access.
2. Size: Same as connected drainage piping.
3. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
4. Closure: Countersunk, drilled-and-threaded brass plug.
5. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
6. Wall Access: Round, flat, stainless-steel cover plate with screw.

E. Cast-Iron Interior Unfinished Accessible Area Cleanouts:

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

2.2 ROOF DRAINS

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

1. Josam Company; Josam Div.
2. MIFAB, Inc.
3. Sioux Chief Mfg. Co.
4. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
5. Tyler Pipe; Wade Div.

6. Watts Drainage Products Inc.
 7. Zurn Plumbing Products Group; Light Commercial Operation.
 8. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Cast-Iron Roof Drains - General:
1. Standard: ASME A112.21.2M.
- C. Cast Iron Roof Drains: Coated cast iron wide flange body, flashing ring/gravel stop, standard under deck clamp and cast iron dome strainer. Provide steel bearing pan in roof decks for added bearing surface area. Roof drain type designations and sizes are indicated on drawings and scheduled below:
1. RD-1: Combination Roof/Overflow Drain Locations "J.R. Smith" 1850 with cast iron dome, bearing pan, 2-inch (50-mm) high dam, deck clamp, and extension flange.
 - a. Coordinate height of required extension flange with insulation thickness at each roof drain.
 2. RD-2: Parapet Drain Locations "J.R. Smith" 1510 with threaded 90 deg. Side outlet and secured nickel bronze flashing clamp and grate.
- D. Roof Drain Downspout Expansion Joints: "J.R. Smith" 1710 Series or equivalent expansion joint for downspouts.
- E. Overflow Drain Downspout Nozzles: "J.R. Smith" 1770 or equivalent nickel , round with removable stainless steel screen.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
1. Install wall cleanouts in all finished spaces.
 2. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 3. Locate at each change in direction of piping greater than 45 degrees.
 4. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 5. Locate at base of each vertical soil and waste stack.
 6. For cleanouts at grade within 5'-0" of building install cleanouts and extension from drain pipe to cleanout at grade where indicated. Set cleanout in poured concrete block 18 inches by 18 inches by 12 inches deep, except where location is in concrete paving. Set top of cleanout 1 inch above surrounding earth grade or flush with grade when installed in paving.
 7. Align square tops parallel with building walls.
- C. For floor cleanouts for piping below floors in unfinished spaces or other spaces as indicated, install cleanout deck plates with top flush with finished floor.

- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 - 1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 - 2. Position roof drains for easy access and maintenance.
 - 3. Install expansion joints in downspouts 25 feet or more in height, where horizontal offset is less than 5 feet.
- F. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- G. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- H. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.3 PROTECTION

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

END OF SECTION 22 1423

SECTION 22 1429 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes sump pumps and accessories, inside the building, for building storm drainage systems.

1.3 ACTION 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. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

- A. Coordinate size and location of basins. Concrete, reinforcement, and formwork requirements are specified in Division 03.

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 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.3 SUBMERSIBLE SUMP PUMPS

- A. Manufacturers:
 - 1. ABS Pumps, Inc.
 - 2. Barnes; Crane Pumps & Systems.
 - 3. Bell & Gossett Domestic Pump; ITT Industries.
 - 4. Federal Pump Corp.
 - 5. Gorman-Rupp Company (The).
 - 6. Goulds Pumps; ITT Industries.
 - 7. Grundfos Pumps Corp.
 - 8. Liberty Pumps.
 - 9. McDonald, A. Y. Mfg. Co.
 - 10. Myers, F. E.; Pentair Pump Group (The).
 - 11. Paco Pumps, Inc.
 - 12. Sta-Rite Industries, Inc.
 - 13. Swaby Manufacturing Co.
 - 14. Weil Pump Company, Inc.
 - 15. Weinman Div.; Crane Pumps & Systems.
 - 16. Zoeller Company.
- B. Description: Factory-assembled and -tested, simplex, single-stage, centrifugal, end-suction, submersible, direct-connected sump pumps complying with UL 778 and HI 1.1-1.2 and HI 1.3 for submersible sump pumps.
- C. Casing: Cast iron; with cast-iron inlet strainer, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.
- D. Impeller: Cast iron or cast bronze; statically and dynamically balanced, semiopen nonclog design, overhung, single suction, keyed and secured to shaft.

- E. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings and double-mechanical seals.
- F. Motor: Hermetically sealed, capacitor-start type, with built-in overload protection; three-conductor waterproof power cable of length required, and with grounding plug and cable-sealing assembly for connection at pump. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."
 - 1. Moisture-Sensing Probe: Internal moisture sensor with moisture alarm.
- G. Pump Discharge Piping: Factory or field fabricated, ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe or bronze pipe.
- H. Basin Cover: Cast iron or steel with bituminous coating and strong enough to support controls.
- I. Controls: NEMA 250, Type 1 enclosure, pedestal mounted unless wall mounting is indicated; with two micropressure switches in NEMA 250, Type 6 enclosures; mounting rod; and electric cables.
- J. Controls: NEMA 250, Type 1 enclosure, pedestal mounted unless wall mounting is indicated; with three mechanical- or mercury-float or micropressure switches in NEMA 250, Type 6 enclosures; mounting rod; and electric cables. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.
 - 1. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
 - 2. High-Water Alarm: Cover-mounted, compression-probe alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - 3. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with micropressure-switch alarm matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - 4. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical- or mercury-float or micropressure -switch alarm matching control and electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

2.4 SUMP-PUMP BASINS AND BASIN COVERS

- A. Basins: Factory-fabricated, watertight, cylindrical, basin sump with top flange and sidewall openings for pipe connections.
 - 1. Material: Cast iron or Fiberglass.
 - 2. Reinforcement: Mounting plates for pumps, fittings, and accessories.
 - 3. Anchor Flange: Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.
- B. Basin Covers: Fabricate metal cover with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - 1. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

2.5 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 22 0513 "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.

2.6 FLEXIBLE CONNECTORS

- A. Manufacturers:
 - 1. Flex-Hose Co., Inc.
 - 2. Flexicraft Industries.
 - 3. Flex-Pression, Ltd.
 - 4. Flex-Weld, Inc.
 - 5. Hyspan Precision Products, Inc.
 - 6. Mercer Rubber.
 - 7. Metraflex, Inc.
 - 8. Proco Products, Inc.
 - 9. Unaflex Inc.
- B. Description: 125-psig minimum working-pressure rating and ends matching pump connection:
 - 1. Bronze Flexible Connectors: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to tubing.
 - 2. Stainless-Steel Flexible Connectors: Corrugated, stainless-steel inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to tubing.

2.7 BUILDING AUTOMATION SYSTEM INTERFACE

- A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
 - 1. On-off status of each pump.
 - 2. High level alarm status.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation and filling are specified in Section 31 2000 "Earth Moving."

3.2 EXAMINATION

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

3.3 INSTALLATION

- A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.
- B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.
- C. Set submersible sump pumps on basin floor. Make direct connections to storm drainage piping.
- D. Install sump pump basins and connect to drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.
- E. Support piping so weight of piping is not supported by pumps.

3.4 CONCRETE

- A. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in Division 22 Section "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to sump pumps to allow service and maintenance.
- C. Connect storm drainage piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Refer to Division 22 Section "Facility Storm Drainage Piping."
 - 1. Install flexible connectors adjacent to pumps in discharge piping.
 - 2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for drainage piping.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test, inspect, and adjust components, assemblies, and equipment installations, including connections.

- B. Perform the following tests and inspections:
 - 1. Perform each visual and mechanical inspection.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Pumps and controls will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

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

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 22 1429

SECTION 22 3100 - DOMESTIC WATER SOFTENERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes commercial water softeners.
 - 1. Chemicals.
 - 2. Water testing kits.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water softeners.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Wiring Diagrams: For power, signal, and control wiring.
- B. Manufacturer Certificates: Signed by manufacturers certifying that water softeners comply with requirements.

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.
- D. Maintenance service agreement.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Salt for Brine Tanks: Furnish same form as and at least the same amount as original load, but not less than 200 lb. Deliver on pallets in 40- or 50-lb packages.
 - 2. Store salt on raised platform where directed by Owner. Do not store in contact with concrete floor.

3. Salt for Brine Tanks: Furnish in same form as and at least four times original load, but not less than 200 lb . Deliver on pallets according to the following:
 - a. Food-Grade Pellet Salt: In 40- or 50-lb packages.
 - b. Plain Pellet Salt: In 40- or 50-lb packages.
 - c. Crystallized Solar Salt: In 40- or 50-lb packages.
 - d. Plain, Brine Block Salt: In 50-lb blocks.

1.6 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of water softeners and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. NSF Compliance as required by authorities having jurisdiction:
 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer shall guarantee that under operating conditions, the water softening system will provide zero GPG hardness as determined by soap or titrate test; that the loss of mineral by attrition will be no greater than 3% per annum for three years and the turbidity of the treated water will be no greater than the untreated water due to the fault of the softener system.
- B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water softener that fail in materials or workmanship within specified warranty period.
 1. Commercial Water Softener, Warranty Period: From date of Substantial Completion.
 - a. Mineral Tanks: Five years.
 - b. Brine Tanks: Five years.
 - c. Controls: Five years.
 - d. Underdrain Systems: Three years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 COMMERCIAL WATER SOFTENERS

- A. Description: Factory-assembled, pressure-type water softener.
1. Available Manufacturers:
 - a. Aquion Water Treatment Products.
 - b. Canney's Inc.
 - c. Culligan International Company.
 - d. Flier's Inc.
 - e. Kinetico Incorporated.
 - f. Mitco Inc.
 - g. Peerless, Inc.
 - h. Sterling Water Treatment.
 2. Comply with NSF 61, "Drinking Water System Components--Health Effects."
 3. Configuration: Twin unit with two mineral tanks and one brine tank.
 4. Mineral Tanks: FRP, pressure-vessel quality.
 - a. Construction: Non-ASME code.
 - b. Pressure Rating: 150 psig minimum.
 - c. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F.
 - d. Freeboard: 50 percent minimum for backwash expansion above normal resin bed level.
 - e. Support: Legs or skirt attached to tank.
 - f. Upper Distribution System: Single, point type, fabricated from galvanized-steel pipe and fittings.
 - g. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from nonmetallic pipe and fittings with individual, fine-slotted, nonclogging plastic strainers; arranged for even flow distribution through resin bed.
 - h. Liner: PE, ABS, or other material suitable for potable water.
 5. Controls: Fully automatic; factory mounted on unit and factory wired.
 - a. Adjustable duration of various regeneration steps.
 - b. Push-button start and complete manual operation.
 - c. Electric time clock and switch for fully automatic operation, adjustable to initiate regeneration at any hour of day and any day of week or at fixed intervals.
 - d. Sequence of Operation: Program multiport pilot-control valve to automatically pressure-actuate main operating valve through steps of regeneration and return to service.
 - e. Pointer on pilot-control valve shall indicate cycle of operation.
 - f. Means of manual operation of pilot-control valve if power fails.

- g. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:
 - 1) Slow opening and closing, nonslam operation.
 - 2) Diaphragm guiding on full perimeter from fully open to fully closed.
 - 3) Isolated dissimilar metals within valve.
 - 4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
 - 5) Sampling cocks for soft water.
 - 6) Special tools are not required for service.
 - h. Flow Control: Automatic, to control backwash and flush rates over wide variations in operating pressures, and that does not require field adjustments.
 - 1) Demand-Initiated Control: Equip each mineral tank of twin mineral-tank units with automatic-reset-head water meters that electrically activate cycle controllers to initiate regeneration at preset total in gallons. Design so heads automatically reset to preset total in gallons for next service run. Include electrical lockout to prevent simultaneous regeneration of both tanks.
- 6. Brine Tank: Combination measuring and wet-salt storing system.
 - a. Tank and Cover Material: Fiberglass, 3/16 inch thick; or molded PE, 3/8 inch thick.
 - b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
 - c. Size: Large enough for at least four regenerations at full salting.
- 7. Factory-Installed Accessories:
 - a. Piping, valves, tubing, and drains.
 - b. Sampling cocks.
 - c. Main-operating-valve position indicators.
 - d. Water meters.
- B. Capacity and Characteristics (Based on Peerless Model 450TCCM):
 - 1. Control Center: Clack WS2
 - 2. Control Valve: Clack MAV.
 - 3. Softener Tank Sizes: 30 inches x72 inches.
 - 4. Maximum Working Pressure: 100-psi
 - 5. Cubic Feet of Resin: 15 cu. ft..
 - 6. Service Pipe Size: 2 inches NPS.
 - 7. Mineral Exchange Capacity: 450,000 grains/cu. ft. per 15 lb of salt.
 - 8. Continuous Service Flow Rate: 75 gpm at 10-psig pressure drop.
 - 9. Peak Service Flow Rate: 150 gpm at 25-psig pressure drop.
 - 10. Backwash Flow: 25 gpm
 - 11. Brine Tank Size: 39 inches x48 inches.

2.3 CHEMICALS

- A. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock.
- B. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

2.4 WATER TESTING SETS

- A. Description: Manufacturer's standard water-hardness testing apparatus and chemicals with testing procedure instructions. Include metal container suitable for wall mounting.

2.5 SOURCE QUALITY CONTROL

- A. Hydrostatically test mineral tanks before shipment to minimum of one and one-half times pressure rating.
- B. Prepare test reports.

PART 3 - EXECUTION

3.1 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for commercial water softeners. Refer to Division 22 Section "Common Work Results for Plumbing."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
- B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.2 WATER SOFTENER INSTALLATION

- A. Install commercial water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
- B. Install brine lines and fittings furnished by equipment manufacturer but not specified to be factory installed.
- C. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
- D. Install water testing sets mounted on wall, unless otherwise indicated, and near water softeners.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Make piping connections between water-softener-unit headers and dissimilar-metal water piping with dielectric connections. Dielectric connections are specified in Division 22 Section "Common Work Results for Plumbing."

- D. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank.
- E. Install shutoff valves on raw-water inlet and soft-water outlet piping of each mineral tank, and on inlet and outlet headers.
 - 1. Metal general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- F. Install pressure gages on raw-water inlet and soft-water outlet piping of each mineral tank. Pressure gages are specified in Division 22 Section "Meters and Gages for Plumbing Piping."
 - 1. Exception: Water softeners with factory-installed pressure gages at locations indicated.
- G. Install valved bypass water piping around water softeners.
 - 1. Metal general-duty valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
 - 2. Water piping is specified in Division 22 Section "Domestic Water Piping."
- H. Install drains as indirect wastes to spill into open drains or over floor drains.
- I. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- J. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Water Analysis: Obtain water sample and perform water analysis.
 - 2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning water softeners that do not pass tests and inspections and retest as specified above.

3.5 STARTUP SERVICE

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

- B. Add water to brine tanks and fill with salt.
- C. Sample water softener effluent after startup and at three consecutive seven-day intervals (total of four samples), and prepare certified test reports for required water performance characteristics.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water softeners. Refer to Division 01 "Demonstration and Training" Section

END OF SECTION 22 3100

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SECTION 22 3450 - DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Fuel-Fired Water Heaters:
 - a. Commercial, condensing storage gas water heaters.
 - b. Expansion tanks.
 - c. Water heater accessories.

1.2 SUBMITTALS

- A. Product Data:
 - 1. For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
 - 2. For solar thermal system components. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters solar thermal system and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. NSF Compliance as required by authorities having jurisdiction:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
3. Comply with NSF 372, "Drinking Water System Components – Lead Content"

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.7 WARRANTY

A. Special Warranty:

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.
 - a. Failures include, but are not limited to, the following:
 - 1) Leaks.
 - b. Warranty Period(s): From date of Substantial Completion:
 - 1) Water Heater: Three years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS WATER HEATERS

- A. Commercial, Condensing, Storage Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

1. Manufacturers: Subject to compliance with requirements, provide Lochinvar "Shield" or an engineer approved equivalent product.
 - a. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
2. Description: Factory fired natural gas direct fired stainless steel heat exchanger mounted on top of storage tank. Manufacturer's proprietary design to provide at least 96 percent combustion efficiency at optimum operating conditions.
3. Storage-Tank Construction: Round vertical steel with 150-psig minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Lining: Glass complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
4. Factory-Installed, Heater Appurtenances:
 - a. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.

- b. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - c. Jacket: Steel with enameled finish.
 - d. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - e. Circulation Pump: All bronze.
- 5. Burner: Premix design, constructed of high temperature stainless steel with woven metal fiber outer covering and variable speed blower.
 - 6. Heat Exchanger: Natural gas direct fired stainless steel heat exchanger.
 - 7. Temperature Control: Adjustable thermostat.
 - 8. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

2.2 EXPANSION TANKS

A. Diaphragm-Type Expansion Tanks:

- 1. 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.
 - a. Manufacturers:
 - 1) AMTROL Inc.
 - 2) Armstrong Pumps, Inc.
 - 3) Bell and Gossett.
 - 4) Flexcon Industries.
 - 5) Honeywell Sparco.
 - 6) Myers, F. E.; Pentair Pump Group (The).
 - 7) Smith, A. O.; Aqua-Air Div.
 - 8) State Industries, Inc.
 - 9) Taco, Inc.
 - 10) Watts Regulator Co.
 - 11) Wessels Co.
 - b. Construction:
 - 1) Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - 2) Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3) Air-Charging Valve: Factory installed.
 - 4) Working-Pressure Rating: 150 psig(1035 kPa).

2.3 WATER HEATER ACCESSORIES

- A. Vacuum Relief Valves: ANSI Z21.22 rated and CSA certified with all brass body and protective cap.
- B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.4 SOURCE QUALITY CONTROL

- A. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
- B. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

- A. Install commercial water heaters on concrete bases.
 - 1. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."
- B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- C. Install gas water heaters according to NFPA 54.
- D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.
- E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
- F. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- G. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.
- H. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.
- I. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

- J. Fill water heaters with water.
- K. Charge diaphragm expansion tanks with air.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to components to allow service and maintenance. Arrange piping for easy removal of components.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- E. Vent and Combustion-Air Connection, Condensing, Gas-Fired Water Heater: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 - 3. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - b. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - c. 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.
 - d. Requirements for Low-Emitting Materials:
 - 1) CPVC solvent cement shall have a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2) PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 4. Slope pipe vent back to water heater.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace system components that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 22 3450

SECTION 22 4000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes plumbing fixtures and related components.
- B. Related Sections include the following:
 - 1. Division 22 Section "Domestic Water Piping Specialties" for mixing valves and specialty fixtures not included in this Section.
 - 2. Division 22 Section "Facility Water Distribution Piping" for exterior plumbing fixtures and hydrants.

1.2 DEFINITIONS

- A. Barrier-Free Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Piping and general-duty valves are included where indicated. Fittings specified in this Section include:
 - 1. Supplies and stops.
 - 2. Faucets and spouts.
 - 3. Drains and tailpieces.
 - 4. Traps and waste pipes.
 - 5. Shower heads.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

- B. Regulatory Requirements: Comply with the following:
 - 1. Michigan Building Code (ANSI117) for plumbing fixtures for people with disabilities.
 - 2. Michigan Plumbing Code.
 - 3. Local authority having jurisdiction.
 - 4. Michigan and local Department of Health requirements.
- C. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- D. NSF Compliance as required by authorities having jurisdiction:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."
 - 3. Comply with NSF 372, "Drinking Water System Components – Lead Content"
- E. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with specified requirements, provide commercial grade plumbing fixtures by one of the following:
 - 1. Lavatories, Water Closets, Urinals:
 - a. American Standard
 - b. Kohler
 - c. Zurn
 - d. Sloan
 - e. Mansfield
 - 2. Stainless Steel Sinks:
 - a. Elkay
 - b. Just
 - 3. Mop Basins:
 - a. Fiat
 - b. Florestone
 - c. Mustee
 - d. ProFlo
 - e. Swan
 - f. Zurn
 - 4. Faucets:
 - a. American Standard
 - b. Chicago Faucet
 - c. Delta
 - d. Elkay

- e. Kohler
 - f. Moen.
 - g. T & S Brass
 - h. Speakman
 - i. Symmons
 - j. Zurn
5. Flush Valves:
- a. Sloan
 - b. Zurn
6. Water Closet Seats:
- a. American Standard
 - b. Bemis
 - c. Centoco
 - d. Church
 - e. Kohler
 - f. Olsonite
 - g. ProFlo
 - h. Zurn
7. Water Coolers:
- a. Elkay
 - b. Oasis
 - c. Halsey-Taylor
 - d. Haws
 - e. Murdock
8. Drinking Fountains:
- a. Elkay
 - b. Oasis
 - c. Halsey-Taylor
 - d. Haws
9. Fixture Supports:
- a. Josam
 - b. Wade
 - c. Zurn
 - d. Jay R. Smith
 - e. MIFAB
 - f. Watts.

2.2 BARRIER-FREE FIXTURES

- A. All fixtures are to be furnished and installed as barrier-free even though the room or area is not totally designed as barrier-free. The exceptions are the mop basins, shampoo sinks, and standard height electric water coolers.

2.3 WATER CLOSETS

- A. WC-1 Water Closets (Wall Mounted Barrier Free): Vitreous china, back outlet, wall hung, 1.6 gallon siphon jet elongated closet bowl, white in color, with 1-1/2" top spud. American Standard "Afwall" Model 3351.001 or equivalent. Provide carriers, TS-1 seat, and FV-1 flush valve as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free requirements.)
- B. WC-2 Water Closets (Wall Mounted): Vitreous china, back outlet, wall hung, 1.6 gallon siphon jet elongated closet bowl, white in color, with 1-1/2" top spud. American Standard "Afwall" Model 3351.001 or equivalent. Provide carriers, TS-1 seat, and FV-2 flush valve as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free requirements.)

2.4 URINALS

- A. UR-1 Urinals (Wall Mounted): Vitreous china, washout 0.5 gallon wall urinal, white in color, with integral extended shields, flushing rim and trap, 3/4" top spud, 2" outlet connection and supporting hangers. American Standard "Washbrook" Model 6590.001 or equivalent. Provide carriers and FV-3 flush valve as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free rim heights.)

2.5 LAVATORIES

- A. LAV-1 Lavatories: 20" x 18" vitreous china lavatory, white in color, with backsplash, front overflow, and chrome plated non-removable grid strainer with tailpiece, fabricated for concealed arm or wall hanger supports. Drill lavatories for single hole faucets. Kohler "Greenwich" Model K-2031 or equivalent. Provide concealed arm carriers, F-3 faucet, trap, and supplies and stops as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free requirements.)
 - 1. Provide offset tailpiece on barrier-free units.
 - 2. Provide plastic under lavatory trap and supplies insulation kit on barrier-free units. Refer to articles below.
 - 3. Provide plastic under lavatory trap and supplies shield on barrier-free units. Refer to articles below.
- B. LAV-2 Lavatories: 20" x 18" vitreous china lavatory, white in color, with backsplash, front overflow, and chrome plated non-removable grid strainer with tailpiece, fabricated for concealed arm or wall hanger supports. Drill lavatories for single hole faucets. Kohler "Greenwich" Model K-2031 or equivalent. Provide concealed arm carriers, F-8 faucet, trap, and supplies and stops as specified in the Articles below. (Refer to mounting heights schedule for Barrier-Free requirements.)
 - 1. Provide offset tailpiece on barrier-free units.
 - 2. Provide plastic under lavatory trap and supplies insulation kit on barrier-free units. Refer to articles below.
- C. LAV-3 Sink Basin by Others: All items indicated by this number are casework with integral sink basins furnished by furniture consultant. Plumbing Installer shall install all faucet trim and accessories and make all final connections for the plumbing system. Provide F-3 faucet, trap, and supplies and stops as specified in the articles below.

1. Provide plastic under lavatory trap and supplies insulation kit on barrier-free units. Refer to articles below.

2.6 MOP BASINS

- A. MB-1 Mop Basin: One piece molded stone 10" high basin with 12" shoulders 24" x 24" overall basin size. Furnish with factory installed 3" drain body with removable stainless steel strainer. Furnish with manufacturer's standard mop hanger and hose and hose bracket accessories for field installation. Mustee Model 63M or equivalent. Provide F-6 faucet as specified in the Articles below.

2.7 FOOD SERVICE EQUIPMENT

- A. EBO-1 Equipment by Others: All items indicated by this number are fixtures and equipment furnished by food service equipment supplier. Equipment supplier will furnish equipment complete with faucet trim, gas cocks, strainers, and tailpieces or other devices integral with or part of his equipment. Plumbing Installer shall provide all cold water, hot water, gases, sanitary lines, vents, supply risers, key stops, traps, etc., required for the equipment. Plumbing Installer shall install all faucet trim and accessories, and make all final connections between plumbing system and kitchen equipment.

2.8 ELECTRIC WATER COOLERS

- A. EWC-1 Electric Water Cooler/Bottle Fill Station: Wall mounted, self-contained barrier free access electric water cooler with fully sealed hermetic refrigeration system. Capacity 8 GPH of 50°F drinking water, 80°F inlet and 90°F ambient. Hand operated, flexible safety bubbler and self-closing push-bar controls located on front, left and right side panels of cabinet, flow regulator from 20 to 100 psi, mounting hangers, stainless steel basin. Refrigeration system is located below basin, 115/1/60 compressor. Provide 1 1/4" P-trap and supply with stop. Bottle filling station shall include electronic sensor for activation with 20 second shut-off timer; 1.1 GPM laminar flow outlet; and stainless steel and anti-microbial plastic housing. Elkay Model EZS8WSLK. Refer to mounting height schedule.
- B. BFS-1 Electric Cooled Bottle Fill Station (Barrier-Free): Wall mounted, self-contained barrier free access electric water cooler bottle fill station with fully sealed hermetic refrigeration system. Capacity 8 GPH of 50°F drinking water, 80°F inlet and 90°F ambient. Bottle filling station shall include electronic sensor for activation with 20 second shut-off timer; 1.1 GPM laminar flow outlet; and stainless steel and anti-microbial plastic housing, filter system, and mounting frame, Refrigeration system is located below basin, 115/1/60 compressor. Provide 1 1/4" P-trap and supply with stop. Elkay Model EZWSM8K or equivalent.

2.9 WASHFOUNTAINS

- A. WF-1 Washfountains: Three station wall hung lavatory system with three lavatories, pedestal, mounting brackets, infrared sensors, low voltage transformer, solenoid valve, liquid soap dispenser, and supply fittings, and thermostatic mixing valve with combination stop, strainer, and check valves. Sloan ELWF-83000 or equivalent.
 1. Color to be selected by Architect from manufacturer's full range, including designer and specialty colors.

2.10 SHOWERS

- A. SH-1 Shower Assembly (Barrier-Free): ASSE 1016 balanced pressure mixing shower valve with single lever blade handle. Valve shall open to cold water first and then through warm (mix) to hot. Valve shall have all operating parts separately replaceable from outside of wall through valve cover plate, ceramic disc valve cartridge, adjustable safety limit stop (set at 110°F), screwdriver stops, 2-way diverter valve, wall supply with 1.5 gpm shower head, inline vacuum breaker, and 1.5 gpm hand held shower head with 36" slide bar and 60" hose. All exposed surfaces shall be chrome-plated. American Standard Model 1662.213 or equivalent.

2.11 SINKS

1. Provide offset tailpiece on barrier-free units.
 2. Provide plastic under lavatory trap and supplies insulation kit on barrier-free units. Refer to articles below.
- B. SK-1 Stainless Steel Sinks: 23-1/2" x 18-1/4" x 4-3/8" undermount, single compartment sink with LKVR-18B stainless steel grid strainer and 1-1/2" O.D. chrome plated brass tailpiece; mounted in solid surface countertop. Fabricate sink from 18-gage, Type 304 stainless steel conforming to ASTM A167, finished one side only in accordance with ASTM A 480 No. 4 finish, and sound deadened. Elkay Model ELUH-AD2115 or equivalent. Provide F-1 faucet, trap, and supplies and stops as specified in the Articles below.
1. Mount using "overhang" installation profile.
- C. SK-2 Stainless Steel Sinks: 30-1/2" x 18-1/2" x 4-3/8" undermount, single compartment sink with LKVR-18B stainless steel grid strainer and 1-1/2" O.D. chrome plated brass tailpiece; mounted in solid surface countertop. Fabricate sink from 18-gage, Type 304 stainless steel conforming to ASTM A167, finished one side only in accordance with ASTM A 480 No. 4 finish, and sound deadened. Elkay Model ELUH-AD2816 or equivalent. Provide F-2 faucet, trap, and supplies and stops as specified in the Articles below.
1. Mount using "overhang" installation profile.
- D. SK-3 Stainless Steel Sinks: 30-1/2" x 18-1/2" x 4-3/8" undermount, single compartment sink with LKVR-18B stainless steel grid strainer and 1-1/2" O.D. chrome plated brass tailpiece; mounted in solid surface countertop. Fabricate sink from 18-gage, Type 304 stainless steel conforming to ASTM A167, finished one side only in accordance with ASTM A 480 No. 4 finish, and sound deadened. Elkay Model ELUH-AD2816 or equivalent. Provide F-7 faucet, trap, and supplies and stops as specified in the Articles below.
1. Mount using "overhang" installation profile.
- E. SK-4 Stainless Steel Service Sinks: 48" x 20" x 8" wall mounted service sink with one piece wall hanger, stainless steel support bracket and 3" cast iron P-trap standard with chrome plated metal strainer. Fabricate sink from 14-gage, Type 304 stainless steel with covered corners and rolled rim. Exposed surfaces shall be finished in accordance with ASTM A-480, No. 4 finish. Elkay Model EWMA-4820 or equivalent. Provide F-4 faucet, and supplies and stops as specified in the Articles below.
- F. SK-5 Stainless Steel Sinks: 36-1/2" x 18-1/2" x 9" undermount, single compartment sink with LKVR-18B stainless steel grid strainer and 1-1/2" O.D. chrome plated brass tailpiece; mounted in solid surface countertop. Fabricate sink from 18-gage, Type 304 stainless steel conforming to ASTM A167, finished

one side only in accordance with ASTM A 480 No. 4 finish, and sound deadened. Elkay Model ELUH-AD2816 or equivalent. Provide F-1 faucet, trap, and supplies and stops as specified in the Articles below.

1. Mount using "overhang" installation profile.

2.12 FAUCETS

- A. F-1 Sink Faucet: Polished chrome plated cast brass deck mount quarter turn faucet with 8" center set, rigid valve body, 5-1/4" rigid gooseneck spout with 1.5 gpm aerator outlet, 4" wrist blade handles indexed "HOT" and "COLD". Chicago Faucet Model 895-317GN2AFCAB or equivalent.
- B. F-2 Sink Faucet: Polished chrome plated cast brass deck mount faucet with pull-down spout, single hole mount, rigid valve body, 9" center-to-center tubular brass spout with dual pattern 1.5 gpm aerator outlet, user adjustable temperature control mixer indexed "HOT" and "COLD". Chicago Faucet Model 434-ABCP or equivalent.
- C. F-3 Lavatory Faucet: Sensor operated hard-wired powered chrome plate cast brass faucet with infrared sensor, solenoid valve, inline filter, and 0.5 gpm vandal-resistant outlet. Sloan SF-2400 or equivalent.
- D. F-4 Sink Faucet: Polished chrome plated cast brass wall mount quarter turn faucet with 8" center set, rigid valve body, rigid gooseneck spout with 1.5 gpm aerator outlet, 4" wrist blade handles indexed "HOT" and "COLD". Chicago Faucet Model Elkay LK940GN08T4H or equivalent.
- E. F-6 Service Faucet: Rough chrome plated cast brass, combination service sink fitting with vacuum breaker, 3/4" threaded hose spout, metal lever handles indexed "HOT" and "COLD" plus red and blue index tabs, wall brace, pail hook, adjustable flanged female supply arms and having integral stops. Chicago Faucet Model 897-RCF or equivalent.
- F. F-7 Sink Faucet: Polished chrome plated cast brass deck mount quarter turn faucet with 8" center set, rigid valve body, 8" rigid gooseneck spout with 1.5 gpm aerator outlet, 4" wrist blade handles indexed "HOT" and "COLD". Chicago Faucet Model 786-E35ABCP or equivalent.
- G. F-8 Lavatory Faucet: Polished chrome plated all metal deck mounted faucet, 4" center set, spout with 0.5 gpm chrome plated constant flow outlet, less pop up drain and hole, single lever metal handle. Kohler Model K-97282-4 or equivalent.

2.13 FLUSH VALVES

- A. FV-1 Flush Valve: Exposed, chrome plated, hard wired sensor operated flush valve for 1.6 gallon water closets, with 24v valve actuator; automatic sensor with manual push button override; chloramine resistant, dual seal diaphragm with a clog resistant, minimum dual filtered by-pass; 1" I.P.S. screw driver operated combination angle back check and stop valve with protective vandal resistant cap; adjustable tailpiece; vacuum breaker flush connection; sweat solder kit; cast wall flange with set screw; and spud coupling and flange for 1-1/2" top spud connection. Sloan Model 111-1.6 ES-S TMO or equivalent.
- B. FV-2 Flush Valve: Quiet, exposed, chrome plated, diaphragm operated flush valve for 1.6 gallon water closets, with non-hold-open low force/ADA compliant handle; chloramine resistant, dual seal diaphragm with a clog resistant dual filtered by-pass; 1" I.P.S. screw driver operated combination angle check and stop valve with protective vandal resistant cap; sweat solder kit; adjustable tailpiece; cast wall flange with

set screw; vacuum breaker; and spud coupling and flange for 1-1/2" top spud connection. Sloan Model 111-DFB.

- C. FV-3 Flush Valve: Quiet, exposed, chrome plated, battery powered sensor operated flush valve for 0.5 gallon urinals, with automatic sensor with manual push button override; chloramine resistant, dual seal diaphragm with a clog resistant dual filtered by-pass; 3/4" I.P.S. screw driver operated combination angle back check and stop valve with protective vandal resistant cap; adjustable tailpiece; vacuum breaker flush connection; sweat solder kit; cast wall flange with set screw; and spud coupling and flange for 3/4" top spud connection. Sloan Model 8186.

2.14 SENSOR FAUCET AND FLUSH VALVE ACCESSORIES

- A. Provide flush valve hardwired power converters, mini junction boxes, and required low voltage wiring for power connection to sensor operated flush valves.
 - 1. Include separate system for each toilet room.
- B. Provide faucet plug-in power converters and required low voltage wiring for power connection to sensor operated faucets.
 - 1. Include separate system for each toilet room.

2.15 TOILET SEATS

- A. TS-1 Elongated, heavy duty, solid white plastic toilet seats with molded-in bumpers, closed back/open front, less cover, and having stainless steel check hinge and stainless steel nuts. Centoco Model 500STSCC or equivalent.

2.16 FIXTURE SUPPORTS

- A. General: All Fixture support carriers to conform to ANSI A112.6.1M (American National Standards Institute).
- B. Urinal and Water Cooler Support Carriers: Wade W-400-AM11-M36 or equivalent foot supported carrier with rectangular structural steel uprights, top support plate, and lower bearing plate with studs.
- C. Water Closet Support Carriers: Wade W-300 series or equivalent foot supported carrier with vertical or horizontal waste fitting configuration as required by waste piping installation. Single closet carriers shall be provided with rear anchoring foot. Closet coupling and fixture support rods shall be of proper length for wall thickness. M4 rod support feet shall be furnished when span from inside of finish block wall to face of carrier faceplate exceeds 6". M4 rod support feet shall also be provided on each water closet carrier installed on stud type wall construction.
- D. Lavatory Support Carriers: "Wade" Model W-520-M36 Series or equivalent concealed arm, foot supported carrier with rectangular structural steel uprights.

2.17 UNDER-LAVATORY GUARDS

A. Under-lavatory Shield-Type Guard:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Truebro by IPS Corporation; Lav-Shield.
 - b. Zurn Industries, Inc.; Rigid Lavatory Enclosure – Vandal Guard.
2. Description: One piece shield for covering supply and drain piping assemblies and other underlav mounted accessories to prevent direct contact with and to provide vandal resistance. Field trim to fit tightly to lavatory and adjacent surfaces.
3. Material and Finish: Rigid, high impact, stain resistant, molded PVC plastic, white.

2.18 FITTINGS, TRIM AND ACCESSORIES

A. Fittings for Plumbing Fixtures: Fittings include the following:

1. Supply Inlets: Copper tube, size required for final connection.
2. Supply Stops: Chrome-plated brass body, angle or straight configuration with compression fittings, loose-key type; size to match inlet pipe and supply riser.
3. Supply Risers: 3/8-inch OD flexible chrome-plated brass tube with 1/2-inch IPS straight or offset, knob-end tailpiece.
4. Traps: Chrome-plated, 17 gauge tubular brass P-trap and wall bend, with slip-joint inlet, wall flange, and escutcheon; same size as fixture outlet connection.
 - a. For concealed applications within water coolers or casework, ASTM F 409 PVC one or two-piece trap and waste to wall maybe used.
 - b. Refer to Section 22 1319 "Sanitary Waste Piping Specialties" for p-trap type trap primers below lavatories and sinks where indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.

2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.
- E. Install wall-mounting fixtures with tubular waste piping attached to supports.
- F. Install counter-mounting fixtures in and attached to casework.
- G. Install fixtures level and plumb according to roughing-in drawings.
- H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
1. Exception: Use ball valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- I. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- J. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- K. Install toilet seats on water closets.
- L. Install traps on fixture outlets.
1. Exception: Omit trap on fixtures with integral traps.
 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- M. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."
- N. Set mop basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."
- O. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."
- P. Install flush valves in accordance with manufacturer's instructions. Adjust settings and verify proper operation.
1. Install flush valves on barrier-free units with handles on wide side of stall.
- Q. Install under-lavatory insulation kits at all lavatory and sink locations in accordance with the following:

1. Cover hot- and cold-water supply risers, stops and handles, tailpiece, trap, and wall bend. Install in accordance with manufacturer's installation instructions. Trim connectors flush so no sharp edges remain.

- R. Install under-lavatory protective shield at all wall mounted lavatory locations in accordance with manufacturer's installation instructions.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

3.4 FIELD QUALITY CONTROL

- A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.5 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Adjust mixing valve maximum temperature limit stop in accordance with manufacturers' recommendations and in compliance with the plumbing code and authority having jurisdiction.
- C. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

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

3.7 PROTECTION

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

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain the following:
 - 1. Faucets.
 - 2. Flush valves.
 - 3. Water coolers
 - 4. Drinking fountains
 - 5. Shower valves.
 - 6. Washfountains.
- B. Refer to Division 01 Section "Demonstration and Training."

3.9 FIXTURE HEIGHT SCHEDULE

- A. Install fixtures to heights above finished floor as indicated.
 - 1. Water Closet:
 - a. Standard: 15 inches to top of bowl rim.
 - b. Barrier Free: 17 to 19 inches, top of seat.
 - 2. Water Closet Flush Valves:
 - a. Standard: 11 inches min. above bowl rim.
 - 3. Urinal:
 - a. Standard: 22 inches to top of bowl rim.
 - b. Barrier Free: 17 inches maximum to top of bowl rim.
 - 4. Urinal Flush Valves:
 - a. Standard: 11 inches min. above top.
 - b. Barrier Free: 46 inches maximum to flush valve handle.
 - 5. Lavatory:
 - a. Standard: 34 inches to top of basin rim.
 - b. Barrier Free: 34 inches to top of basin rim.
 - 6. Water Cooler:
 - a. Standard Adult: Minimum 38 inches and maximum 43 inches to spout outlet.
 - b. Barrier Free: Maximum 36 inches to spout outlet.

3.10 FIXTURE ROUGH-IN SCHEDULE

A. Line sizes indicated below are run-out sizes, reduce size as required at connection to fixture. Main lines and drops shall be installed in sizes as indicated on drawings.

1. Water Closet (Flush Valve Type):
 - a. Cold Water: 1 Inch.
 - b. Waste: 4 Inch.
 - c. Vent: 2 Inch.
2. Urinal (Flush Valve Type):
 - a. Cold Water: 1 Inch.
 - b. Waste: 2 Inch.
 - c. Vent: 1-1/2 Inch.
3. Lavatory:
 - a. Hot Water: 1/2 Inch.
 - b. Cold Water: 1/2 Inch.
 - c. Waste: 1-1/2 Inch.
 - d. Vent: 1-1/4 Inch.
4. Sink:
 - a. Hot Water: 1/2 Inch.
 - b. Cold Water: 1/2 Inch.
 - c. Waste: 2 Inch.
 - d. Vent: 1-1/2 Inch.
5. Water Cooler:
 - a. Cold Water: 1/2 Inch.
 - b. Waste: 1-1/4 Inch.
 - c. Vent: 1-1/4 Inch.
6. Mop Basin:
 - a. Hot Water: 3/4 inch.
 - b. Cold Water: 3/4 inch.
 - c. Waste: 3 inch.
 - d. Vent: 1-1/2 inch.

END OF SECTION 22 4000

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SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Sleeve-seal systems.
4. Sleeves.
5. Stack-sleeve fittings.
6. Escutcheons.
7. Grout.
8. Equipment installation requirements common to equipment sections.
9. Painting and finishing.
10. Concrete bases.
11. Supports and anchorages.

1.2 ACTION SUBMITTALS

A. Product Data: For dielectric fittings.

1.3 QUALITY ASSURANCE

- A. Provide HVAC systems, equipment, and materials in accordance with Michigan Mechanical Code and other applicable codes and regulations, and with authorities having jurisdiction.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. 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.
- D. Electrical Characteristics for HVAC 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.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Deliver products to project properly identified with names, model numbers, types, grades, compliance labels, and similar information needed for distinct identifications; adequately packaged and protected to prevent damage during shipment, storage, handling, and up to substantial completion. Coordinate deliveries of mechanical materials and equipment to minimize construction site congestion.

1.5 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and sleeves in structural components.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

1.6 PROJECT COMMISSIONING

- A. Project is attempting to obtain Leed Certification and has an independent commissioning authority (CxA). Contractors for this project shall meet CxA requirements and shall coordinate with and participate in commissioning activities.

PART 2 - PRODUCTS

2.1 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.2 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: 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.
 - 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.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, 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, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.3 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded end connections that match piping system materials.
 - 1. Insulating Material: Suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F with threaded end connections.
- C. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- D. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.

2.4 SLEEVE-SEAL SYSTEMS

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

2.5 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. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.6 STACK-SLEEVE FITTINGS

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

2.7 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Cast-Brass Type: With polished, chrome-plated or rough-brass finish and setscrew fastener.
- C. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
- D. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- E. Split-Casting Brass Type: With polished, chrome-plated or rough-brass finish and with concealed hinge and setscrew.
- F. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed or exposed-rivet hinge, and spring-clip fasteners.

2.8 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.

2.9 MECHANICAL ROOF PENETRATIONS

- A. Roof Curbs for Duct Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, and wood nailer. Size as required to suit roof opening and ductwork. Overall minimum height shall be 12 inches above roof insulation. Provide curbs with level tops and bottoms to match roof slope. Provide galvanized steel flashing and seal water tight. Provide insulation on interior flashing surfaces exposed to building air. Pate or equivalent.
- B. Pipe Curbs for Single or Multiple Pipe Penetrations: Prefabricated heavy-gage galvanized steel or aluminum curb with mitered and welded corners, minimum 1 1/2 inch thick rigid fiberglass insulation adhered to inside walls, built-in cant and mounting flange for roof decks, wood nailer, and acrylic clad ABS plastic cover(s), PVC boot(s), and stainless steel clamps.. Size as required to suit roof opening and

piping. Overall minimum height shall be 12 inches above roof insulation. Provide curbs with level tops and bottoms to match roof slope. Pate or equivalent.

- C. Pipe Curbs for Single Pipe Penetrations: All roof pipe penetrations up to 10" O.D. shall be flashed and sealed using a Pate or equivalent pipe seal, consisting of a spun aluminum base having a minimum five inch roof surface flange, a stepped polyvinyl chloride boot to be secured to the base and the pipe with adjustable stainless steel clamps as furnished.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.
 - 1. Drawings are diagrammatic with no attempt made to show every ell, tee, transition, fitting, or appurtenance. Provide installations that are complete in every detail, compliant with all applicable codes, and as required to provide a fully functional and operational system even though every item is not specifically indicated.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping 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.

3.2 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and finished floors according to the following:
 - 1. Escutcheons for New Piping:

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

3.3 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
 1. Sleeves are not required for core-drilled holes.
- 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.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch 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 07 9200 "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 07 8413 "Penetration Firestopping."

3.4 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 07 6200 "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 07 8413 "Penetration Firestopping."

3.5 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.

3.6 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: Cast-iron wall sleeves, galvanized-steel wall sleeves, or galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves, galvanized-steel wall sleeve, 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.
 - 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.
 - 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.
 - 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.
 - 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: Stack-sleeve fittings.
 - b. Piping NPS 6 and Larger: 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.

3.7 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.8 PIPING CONNECTIONS

- A. 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. Wet Piping Systems: Install dielectric unions, dielectric couplings, or dielectric nipple fittings to connect piping materials of dissimilar metals.

3.9 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Sequence, coordinate, and integrate installations of mechanical equipment, giving particular attention to large equipment requiring positioning prior to closing in the building.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations.
 - 1. Extend grease fittings to accessible locations.
- E. Install equipment to allow right of way for piping installed at required slope.
- F. Installing contractor shall bear all additional costs, including that of Architect/Engineer redesign and that of other trades, incurred as a result of installation of other than scheduled equipment.
- G. Verify final equipment locations for roughing-in.
- H. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.10 PAINTING

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

3.11 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches 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 for cast-in-place concrete.

3.12 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.13 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
 - 1. Clean surfaces that will come into contact with grout.
 - 2. Provide forms as required for placement of grout.
 - 3. Avoid air entrapment during placement of grout.
 - 4. Place grout, completely filling equipment bases.
 - 5. Place grout on concrete bases and provide smooth bearing surface for equipment.
 - 6. Place grout around anchors.
 - 7. Cure placed grout.

3.14 MECHANICAL ROOF PENETRATIONS

- A. Install mechanical roof penetrations in accordance with roof curb manufacturer's recommendations and in strict compliance with roofing manufacturer's requirements.
 - 1. Roofs with Warranty: Roof penetrations and curbs shall be installed in such a manner to maintain roofing warranty.
- B. Roof Curbs for Duct Penetrations: Provide galvanized steel flashing and seal water tight. Provide insulation on interior flashing surfaces exposed to building air.
- C. Pipe Curbs for Pipe Penetrations: Secure boot to curb base and secure boot to pipe with adjustable stainless steel clamps.

3.15 INSTALLATION OF ACCESS DOORS

- A. Where lay-in ceilings are used, the access to ceiling space is provided through the removable ceiling panels. Where access is required to valves, pipes, dampers or other devices in spaces above non-removable ceilings or in chases, the Contractor requiring the access doors shall provide access doors. Access doors required in rated walls and ceiling shall bear the same rating. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
 - 1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
 - 2. Adjust hardware and panels after installation for proper operation.

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END OF SECTION 23 0500

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SECTION 23 0513 - 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 ac power systems up to 600 V and installed at equipment manufacturer's factory.

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.
- B. For motors using variable frequency controller, motors to be designed for such application and suitable for use throughout speed range without overheating.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.

1. Provide premium efficient motors where scheduled or when used with a variable frequency controller.
- 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: Class B.
- 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: Manufacturer's standard material.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with controller.
 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 3. Shaft Grounding Ring: Factory installed Aegis Model SGR shaft grounding ring consisting of maintenance free, circumferential, bearing protection ring with conductive micro fiber shaft contacting material.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 1. Permanent-split capacitor.
 2. Split phase.
 3. Capacitor start, inductor run.
 4. Capacitor start, capacitor run.

- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.6 ELECTRONIC COMMUTATION MOTOR (ECM)

- A. Description: Motor to be an electronic commutation motor (ECM) specifically designed for direct drive fan applications. Motors shall be permanently lubricated with heavy-duty ball bearings to match the fan load and prewired to the specific voltage and phase. Internal motor circuitry shall convert AC power supplied to the fan to DC power to operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0513

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SECTION 23 0516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal-bellows expansion joints.
2. Expansion compensators.
3. Rubber expansion joints.
4. Flexible-hose expansion joints.
5. Packed slip expansion joints.
6. Flexible ball joints.
7. Pipe bends and loops.
8. Alignment guides and anchors.

1.2 DEFINITIONS

- A. BR: Butyl rubber.
- B. Buna-N: Nitrile rubber.
- C. CR: Chlorosulfonated polyethylene synthetic rubber.
- D. CSM: Chlorosulfonyl-polyethylene rubber.
- E. EPDM: Ethylene-propylene-diene terpolymer rubber.
- F. NR: Natural rubber.
- G. PTFE: Polytetrafluoroethylene plastic.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and bends.
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.

1.5 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Product Certificates: For each type of pipe expansion joint, signed by product manufacturer.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
 2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

- A. Metal-Bellows Expansion Joints: ASTM F 1120, circular-corrugated-bellows type with external tie rods.
 1. provide products by one of the followingBasis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Adscos Manufacturing, LLC.
 - b. Anamet, Inc.
 - c. Badger Industries.
 - d. Expansion Joint Systems, Inc.
 - e. Flex-Hose Co., Inc.
 - f. Flexicraft Industries.
 - g. Flex-Pression, Ltd.
 - h. Flex-Weld, Inc.
 - i. Hyspan Precision Products, Inc.
 - j. Metraflex, Inc.
 - k. Piping Technology & Products, Inc.
 - l. Proco Products, Inc.
 - m. Senior Flexonics, Inc.; Pathway Division.

- n. Tozen America Corp.
 - o. Unaflex Inc.
 - p. WahlcoMetroflex.
 - q.
- 2. Metal-Bellows Expansion Joints for Copper Piping: Single -ply phosphor-bronze bellows, copper pipe end connections, and brass shrouds.
 - 3. Metal-Bellows Expansion Joints for Stainless-Steel Waterway: Single-ply stainless-steel bellows, stainless-steel-pipe end connections, and steel shroud.
 - 4. Metal-Bellows Expansion Joints for Steel Piping: Single -ply stainless-steel bellows, steel pipe end connections, and carbon-steel shroud.
 - 5. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
 - 6. Configuration: Single -bellows type with base, unless otherwise indicated.
 - 7. End Connections: Flanged or weld.
- B. Expansion Compensators: Double-ply corrugated steel, stainless-steel, or copper-alloy bellows in a housing with internal guides, antitorque device, and removable end clip for positioning.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Adscio Manufacturing, LLC.
 - b. Flexicraft Industries.
 - c. Flex-Pression, Ltd.
 - d. Flex-Weld, Inc.
 - e. Hyspan Precision Products, Inc.
 - f. Metraflex, Inc.
 - g. Senior Flexonics, Inc.; Pathway Division.
 - h. Unaflex Inc.
 - i.
 - 4. Minimum Pressure Rating: 150 psig, unless otherwise indicated.
 - 5. Configuration for Copper Piping: Two-ply phosphor-bronze or stainless-steel bellows and bronze or stainless-steel shroud.
 - 6. Configuration for Steel Piping: Two-ply stainless-steel bellows and carbon-steel shroud.
 - 7. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint.
 - 8. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Solder joint.
 - 9. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
 - 10. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Flanged.
- C. Rubber Expansion Joints: ASTM F 1123, fabric-reinforced rubber with external control rods and complying with FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 3. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Flex-Weld, Inc.
 - d. Garlock Sealing Technologies.
 - e. General Rubber Corp.
 - f. Mason Industries, Inc.; Mercer Rubber Co.
 - g. Metraflex, Inc.
 - h. MG Piping Products Co.
 - i. Proco Products, Inc.
 - j. Red Valve Company, Inc.
 - k. Senior Flexonics, Inc.; Pathway Division.
 - l. Tozen America Corp.
 - m. Unaflex Inc.
 - n. Vibration Mountings & Controls, Inc.
 - o.
 4. Arch Type: Single arches.
 5. Spherical Type: Single spheres.
 - a. Minimum Pressure and Temperature Ratings for NPS 1-1/2 to NPS 4: 150 psig at 220 deg F.
 - b. Minimum Pressure and Temperature Ratings for NPS 5 and NPS 6: 140 psig at 200 deg F.
 6. Material: EPDM.
 7. End Connections: Full-faced, integral, steel flanges with steel retaining rings.
- D. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 3. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Flex-Pression, Ltd.
 - d. Metraflex, Inc.
 - e.
 4. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.
 5. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.
 - a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
 - b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
 6. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with solder- joint end connections.

- a. NPS 2 and Smaller: Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
 - b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
 - c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.
 - d. NPS 2 and Smaller: Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.
 - e. NPS 2-1/2 to NPS 6: Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
 - f. NPS 8 and Larger: Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.
- E. Packed Slip Expansion Joints: ASTM F 1007, carbon-steel, packing type designed for repacking under pressure and pressure rated for 250 psig at 400 deg F minimum. Include asbestos-free PTFE packing, compound limit stops, and drip connection if used for steam piping.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Adscio Manufacturing, LLC.
 - b. Advanced Thermal Systems, Inc.
 - c. Hyspan Precision Products, Inc.
 - d.
 3. Configuration: Single -joint class with base, unless otherwise indicated.
 4. End Connections: Flanged or weld ends to match piping system.
- F. Flexible Ball Joints: Carbon-steel assembly with asbestos-free composition packing, designed for 360-degree rotation and angular deflection, and 250 psig at 400 deg F minimum pressure rating; complying with ASME Boiler and Pressure Vessel Code: Section II, "Materials," and with ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
1. Angular Deflection for NPS 6 and Smaller: 30-degree minimum.
 2. Angular Deflection for NPS 8 and Larger: 15-degree minimum.
 3. End Connections for NPS 2 and Smaller: Threaded.
 4. End Connections for NPS 2-1/2 and Larger: Flanged.
 5. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 6. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advanced Thermal Systems, Inc.
 - b. Hyspan Precision Products, Inc.
 - c.

2.2 ALIGNMENT GUIDES

- A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

- a. Adscos Manufacturing, LLC.
- b. Advanced Thermal Systems, Inc.
- c. Flex-Hose Co., Inc.
- d. Flexicraft Industries.
- e. Flex-Weld, Inc.
- f. Hyspan Precision Products, Inc.
- g. Metraflex, Inc.
- h. Piping Technology & Products, Inc.
- i. Senior Flexonics, Inc.; Pathway Division.
- j.

2.3 MATERIALS FOR ANCHORS

- A. Steel Shapes and Plates: ASTM A 36/A 36M.
- B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.
- C. Washers: ASTM F 844, steel, plain, flat washers.
- D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.
 1. Stud: Threaded, zinc-coated carbon steel.
 2. Expansion Plug: Zinc-coated steel.
 3. Washer and Nut: Zinc-coated steel.
- E. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened portland cement concrete, and tension and shear capacities appropriate for application.
 1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
 3. Washer and Nut: Zinc-coated steel.
- F. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.
- G. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink, nonmetallic grout; suitable for interior and exterior applications.
 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install manufactured, nonmetallic expansion joints according to FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
- B. Install expansion joints of sizes matching size of piping in which they are installed.
- C. Install alignment guides to allow expansion and to avoid end-loading and torsional stress.

3.2 PIPE BEND AND LOOP INSTALLATION

- A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
- B. Attach pipe bends and loops to anchors.
 - 1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

3.3 SWING CONNECTIONS

- A. Connect risers and branch connections to mains with at least four pipe fittings, including tee in main.
- B. Connect risers and branch connections to terminal units with at least four pipe fittings, including tee in riser.
- C. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.4 ALIGNMENT-GUIDE INSTALLATION

- A. Install guides on piping adjoining pipe expansion fittings and loops.
- B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

- A. 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.
- B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

- C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.
- D. Install pipe anchors according to expansion-joint manufacturer's written instructions if expansion joints or compensators are indicated.
- E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

END OF SECTION 23 0516

SECTION 23 0519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft.
 - 2. Blue Ribbon Corp.
 - 3. Marsh Bellofram.
 - 4. Miljoco Corp.
 - 5. Terice, H. O. Co.
 - 6. Weiss Instruments, Inc.
 - 7. Weksler Instruments.
- B. Case: Metal or plastic, 9 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

- H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.
- C. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft.
 - 2. Blue Ribbon Corp.
 - 3. Marsh Bellofram.
 - 4. Miljoco Corp.
 - 5. Terice, H. O. Co.
 - 6. Weiss Instruments, Inc.
 - 7. Weksler Instruments.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Liquid-filled type, drawn steel or cast aluminum, 4-1/2-inch diameter.
 - 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 - 3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
 - 4. Movement: Mechanical, with link to pressure element and connection to pointer with front recalibration.
 - 5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
 - 6. Pointer: Red or other dark-color metal.
 - 7. Window: Glass or plastic.
 - 8. Ring: Metal.
 - 9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
 - 10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
 - 11. Range for Fluids under Pressure: Two times operating pressure.
- C. Pressure-Gage Fittings:
 - 1. Valves: NPS 1/4 brass:
 - a. Ball valve for water systems.
 - b.
 - 2. Tubing: NPS 1/4(DN 8) steel or copper.
 - 3. Snubbers: ASME B40.5, NPS 1/4(DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.
 - 4.

2.4 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Blue Ribbon Corp.
 - 2. Flow Design, Inc.
 - 3. MG Piping Products Co.
 - 4. National Meter, Inc.
 - 5. Peterson Equipment Co., Inc.
 - 6. Sisco Manufacturing Co.
 - 7. Trerice, H. O. Co.
 - 8. Watts Industries, Inc.; Water Products Div.
- B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.
- C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- D. Core Inserts: One or two self-sealing rubber valves.
 - 1. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.
 - 2. Insert material for oil, or gas service at 20 to 200 deg F shall be CR.
- E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
 - 1. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

- A. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 4. Inlet and outlet of each hydronic heat exchanger.
 - 5. Elsewhere as indicated on drawings.
- B. Provide the following temperature ranges for thermometers:
 - 1. Heating Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
 - 2. Condenser Water: 0 to 160 deg F, with 2-degree scale divisions.
 - 3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.
 - 4. Steam and Condensate: 30 to 300 deg F, with 5-degree scale divisions.
 - 5. Air Ducts: 30 to 240 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

- A. Install pressure gages in the following locations:
 - 1. At discharge of each pressure-reducing valve
 - 2. At heating-water inlets and outlets of boilers
 - 3. At chilled- and condenser-water inlets and outlets of chillers
 - 4. Across suction and discharge of each base mounted pump
 - 5. Elsewhere as indicated on drawings.

3.3 INSTALLATIONS

- A. Install direct-mounting thermometers and adjust vertical and tilted positions.
- B. Install thermowells with socket extending one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
 - 1. Provide elbows as required to install gauges at location and angle readable from standing position on floor.
- D. Install ball valve and snubber fitting in piping for each pressure gage for fluids.
- E. Install test plugs in tees in piping.

3.4 CONNECTIONS

- A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.

3.5 ADJUSTING

- A. Calibrate meters according to manufacturer's written instructions, after installation.
- B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 23 0519

SECTION 23 0523 – GENERAL DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Copper-alloy ball valves.
 - 2. Ferrous-alloy butterfly valves.
 - 3. Bronze check valves.
 - 4. Gray-iron swing check valves.
 - 5. Cast-iron gate valves.
 - 6. Bronze globe valves.
 - 7. Cast-iron globe valves.
- B. Related Sections include the following:
 - 1.
 - 2. Division 23 piping Sections for specialty valves applicable to those Sections only.
 - 3. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and charts.
 - 4. Division 23 Section "Instrumentation and Control for HVAC" for control valves and actuators.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.3 QUALITY ASSURANCE

- A. ASME Compliance: ASME B31.9 for building services piping valves.
- B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.

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- 2. Protect valve ends from damage.

3. Set gate, and globe valves closed to prevent rattling.
4. Set ball valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

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

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 VALVES, GENERAL

- A. Refer to Part 3 "Valve Applications" Article for applications of valves.
- B. Bronze Valves: NPS 2 and smaller with threaded ends.
- C. Ferrous Valves: NPS 2-1/2 and larger with flanged ends, unless otherwise indicated.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
1. Lever Handle: For quarter-turn valves NPS 4(DN 100) and smaller.

2. Gear Drive: For quarter-turn valves NPS 5(DN 125) and larger.

- 3. Handwheel: For valves other than quarter-turn types.
- F. Extended Valve Stems: On insulated valves.
- G. Extended Valve Stems: Include the following on 1-1/2" and larger insulated valves in chilled water lines:
 - 1. 2-inch stem extensions.
 - 2. Extended operating handle of non-thermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
- H. Memory Stops: Include memory stops that are fully adjustable after insulation is applied.
- I. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
- J. Valve Solder Ends: Solder joint with sockets according to ASME B16.18.
 - 1. Caution: Use solder with melting point below 840 deg F(454 deg C) for angle, check, gate, and globe valves; below 421 deg F(216 deg C) for ball valves.
- K. Valve Threaded Ends: Threaded with threads according to ASME B1.20.1.
- L. Valve Bypass and Drain Connections: MSS SP-45.

2.3 COPPER-ALLOY BALL VALVES

- A. Manufacturers:
 - 1. Two-Piece, Copper-Alloy Ball Valves:
 - a. Apollo Valves.
 - b. Crane.
 - c. Hammond Valve.
 - d. Jomar International, LTD.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Watts Industries, Inc.; Water Products Div.
- B. Copper-Alloy Ball Valves, General: MSS SP-110.
- C. Two-Piece, Copper-Alloy Ball Valves: **Cast bronze** threaded two-piece body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
- D. High Performance Ball Valves, NPS 2 and Smaller: 600psi WOG pressure, 150 SWP, two piece bronze body, full port, stainless steel ball, replaceable "TFE" seats and seal, blowout proof stem, vinyl covered handle, and threaded ends.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

- A. Manufacturers:

1. Lug Type, Ferrous-Alloy Butterfly Valves:
 - a. Apollo Valves.
 - b. Crane.
 - c. General Signal; DeZurik Unit.
 - d. Hammond Valve.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Watts Industries, Inc.; Water Products Div.
 - B. Ferrous-Alloy Butterfly Valves, General: MSS SP-67, Type I, for tight shutoff.
 - C. Flangeless, 200-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Lug type with one- or two-piece stainless steel stem, ASTM A 126 cast iron or ASTM A 536 ductile iron body, EPDM seat, aluminum bronze disc.
 - D. Flangeless, 200-psig CWP Rating, Ferrous-Alloy Butterfly Valves: Wafer type with one -piece stem.
 - E. High Performance Butterfly Valves, NPS 2-1/2 and Larger: 150 psi WCB cast steel bodies, , lug style, stainless steel disc, RTFE/stainless garter spring seats, stainless steel stem.
- 2.5 BRONZE CHECK VALVES
- A. Manufacturers:
 1. Type 4, Bronze, Swing Check Valves with Nonmetallic Disc:
 - a. Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Industries, Inc.; Water Products Div.
 - B. Bronze Check Valves, General: MSS SP-80.
 - C. Type 4, Class 125, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.
 - D. Type 4, Class 150, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.
- 2.6 GRAY-IRON SWING CHECK VALVES
- A. Manufacturers:
 1. Gray-Iron Swing Check Valves:
 - a. Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Industries, Inc.; Water Products Div.
 - B. Gray-Iron Swing Check Valves, General: MSS SP-71.
 - C. Class 125, gray-iron, swing check valves with bronze trim and asbestos-free gasket.

- D. Class 250, gray-iron, swing check valves bronze trim and asbestos-free gasket.

2.7 BRONZE GATE VALVES

A. Manufacturers:

1. Type 2, Bronze, Rising-Stem, Solid-Wedge Gate Valves:
 - a. Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Industries, Inc.; Water Products Div.

- B. Bronze Gate Valves, General: MSS SP-80, with ferrous-alloy handwheel.

- C. Type 2, Class 125, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

- D. Type 2, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

2.8 CAST-IRON GATE VALVES

A. Manufacturers:

1. Type I, Cast-Iron, Rising-Stem Gate Valves:
 - a. Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Industries, Inc.; Water Products Div.

- B. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

- C. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

- D. Class 250, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

2.9 BRONZE GLOBE VALVES

A. Manufacturers:

1. Globe Valves with Nonmetallic Disc:
 - a. Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Industries, Inc.; Water Products Div.
 - B. Bronze Globe Valves, General: MSS SP-80, with ferrous-alloy handwheel.
 - C. Type 1, Class 125, Bronze Globe Valves: Bronze body with PTFE or TFE disc.
 - D. Type 2, Class 150, Bronze Globe Valves: Bronze body with PTFE or TFE disc and union-ring bonnet.
- 2.10 CAST-IRON GLOBE VALVES
- A. Manufacturers:
 1. Type I, Cast-Iron Globe Valves with Metal Seats:
 - a. Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Industries, Inc.; Water Products Div.
 - B. Cast-Iron Globe Valves, General: MSS SP-85.
 - C. Type I, Class 125, Cast-Iron Globe Valves: Gray-iron body with bronze seats.
 - D. Type I, Class 250, Cast-Iron Globe Valves: Gray-iron body with bronze seats.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 - 1. For Water Systems:
 - a. Shutoff Service: Ball or butterfly valves.
 - b. Throttling Service: Ball or butterfly valves.
 - c. Balancing Valve Service: Throttling valve with memory stop.
- B. Select valves, except lug types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends.
 - 2. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 3. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends.
 - 4. For Steel Piping, NPS 5 and Larger: Flanged ends.
- C. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.
- D. Hydronic Water Piping: For hot water heating, chilled water, condenser water, piping systems, use the following types of valves:
 - 1. Ball Valves, NPS 2 and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
 - 2. Butterfly Valves, NPS 2-1/2 and Larger: Lug type, 200-psig CWP rating, ferrous alloy, with aluminum bronze disc and EPDM rubber seat and seals.
 - 3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125 or 150, bronze.
 - 4. Swing Check Valves, NPS 2-1/2 and Larger: Class 125, gray iron.

3.3 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping joint construction.

- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

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 if persistent leaking occurs.

END OF SECTION 23 0523

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Pipe stands.
 - 7. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 fire-suppression sections for pipe hangers for fire-protection piping.
 - 3. Division 23 Section(s) "Metal Ducts" for duct hangers and supports.

1.2 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
2. Standard: MFMA-4.
3. Channels: Continuous slotted steel channel with intumed lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Non-MFMA 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.
3. Channels: Continuous slotted steel channel with intumed lips.
4. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.4 THERMAL-HANGER SHIELD INSERTS

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

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

2.5 FASTENER SYSTEMS

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

2.6 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: Plastic unit with top configuration to support pipe for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece plastic or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 1. Base: Plastic or stainless steel.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 1. Bases: One or more plastic.
 - 2. Vertical Members: Two or more protective-coated-steel channels.
 - 3. Horizontal Member: Protective-coated-steel channel.
 - 4. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use thermal-hanger shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.

5. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 6. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 7. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 9. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
 10. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 11. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.
 12. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42, if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
- I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- J. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 4. C-Clamps (MSS Type 23): For structural shapes.
 5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 6. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.

- L. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 - 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 - 3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- M. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 - 2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
- N. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
 - 1. Use powder-actuated fasteners only in concrete construction that is suitable for their installation.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
- G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- 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.
- L. Load Distribution: Install hangers and supports so 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 so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.
- N. Insulated Piping: Comply with the following:
 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 4. Shield Dimensions for Pipe: Not less than the following:

- a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
- 5.
 6. Insert Material: Length at least as long as protective shield.
 7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touch Up: 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 A 780.

END OF SECTION 23 0529

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SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Pipe labels.
 - 3. Stencils.
 - 4. Valve tags.

1.2 ACTION SUBMITTALS

- A. Valve Schedules: For each piping system.

1.3 COORDINATION

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

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 "Pipe Labeling Guide" for color scheme, length of field and letter height.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: Black.
 - 3. Background Color: White.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - a. Size of label shall be proportional to equipment size.

6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic label including flow arrow formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic label with contact-type, permanent-adhesive backing. Include wrap around flow arrow tape with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service matching designations or abbreviations as used on Drawings.

2.3 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
 1. Stencil Material: Fiberboard or metal.
 2. Stencil Paint: Exterior, gloss, black enamel unless otherwise indicated. Paint may be in pressurized spray-can form.
 3. Identification Paint: Exterior enamel in colors according to ASME A13.1 unless otherwise indicated.

2.4 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 1. Provide glass front frame for each valve schedule for mounting in building mechanical room.

2. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

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

3.3 PIPE LABEL INSTALLATION

- A. Pipe Label Applications: Install pipe labels as follows:
 1. Use pretensioned pipe labels or self-adhesive pipe labels.
- 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, on each piping system.
 1. Identification Paint: Use for contrasting background.
 2. Stencil Paint: Use for pipe marking.
- C. Locate pipe labels where piping is concealed above ceilings or exposed in unfinished mechanical rooms; accessible maintenance spaces such as shafts, tunnels, and plenums as follows:
 1. Near each valve and control device.
 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 5. Near major equipment items and other points of origination and termination.
 6. Spaced at maximum intervals of 50 feet along each run.

3.4 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; equipment shutoff valves; convenience and hose connections; and HVAC terminal devices and similar roughing-in connections of end-use units. List tagged valves in a valve schedule.
- B. Install glass front frame valve schedule in building mechanical room. Locate at Owners representative approved location.

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END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Balancing Air Systems.
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
2. Balancing Hydronic Piping Systems.
 - a. Variable-flow hydronic systems.
3. Testing, Adjusting, and Balancing Equipment.
 - a. Motors.
 - b. Chillers.
 - c. Condensing units.
 - d. Boilers.
 - e. Heat-transfer coils.
4. Testing, adjusting, and balancing existing systems and equipment.
5. Sound tests.
6. Vibration tests.
7. Duct leakage tests.
8. Control system verification.

1.2 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.
- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.3 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the Owner, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 90 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Contract Documents Examination Report: Within 90 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- D. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- E. Strategies and Procedures Plan: Within 90 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
- F. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- G. System Readiness Checklists: Within 90 days of Contractor's Notice to Proceed, submit system readiness checklists as specified in "Preparation" Article.
- H. Examination Report: Submit a summary report of the examination review required in "Examination" Article.
- I. Certified TAB Reports: Submit four copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- J. Certified TAB reports.
- K. Sample report forms.
- L. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.
 - 3. Application.
 - 4. Dates of use.

- 5. Dates of calibration.

1.5 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC NEBB or TABB.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 FIELD CONDITIONS

- A. Owner Occupancy: Owner will occupy the site and existing building during TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- C. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Perform TAB after leakage and pressure tests on distribution systems have been satisfactorily completed.

1.8 PROJECT COMMISSIONING

- A. Project is attempting to obtain Leed Certification and has an independent commissioning authority (CxA). TAB Specialists for this project shall meet CxA requirements and shall coordinate with and participate in commissioning activities.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage one of the following:
 - 1. Subject to compliance with requirements, provide the services of one of the following:
 - a. International Test and Balancing, Inc.
 - b. Quality Air Service, Inc.
 - c. Control Solutions.
 - d. Mechanical Testing Services, Inc.
 - e. Great Lakes Balancing.
 - f. Third Coast Testing and Balancing.
 - g. Aireconomics.
 - h. Integrity Test and Balance, Inc
 - i. Aerodynamics Inspecting Co.
 - j. Enviro-Aire/Total Balance Co.
 - k. Air Flow Testing Inc.
 - l. Absolute Balancing Co.
 - m. Hi-Tech Testing and Balancing Inc.
 - n. Pro-MEC Engineering Services, Inc
 - o. Kinetix Testing and Commissioning
 - p. Environmental Test and Balancing, Inc.

3.2 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- D. Examine the approved submittals for HVAC systems and equipment.
- E. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- F. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

- G. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- H. Examine equipment performance data.
- I. Examine equipment performance data including fan and pump curves.
 - 1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 - 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- J. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- K. Examine test reports specified in individual system and equipment Sections.
- L. Examine HVAC equipment and verify that equipment with functioning controls is ready for operation.
- M. 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.
- N. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- O. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- P. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- Q. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- R. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- S. Examine system pumps to ensure absence of entrained air in the suction piping.
- T. Examine operating safety interlocks and controls on HVAC equipment.
- U. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

- A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
 2. Strategies and step-by-step procedures for balancing the systems.
 3. Instrumentation to be used.
 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
1. Airside:
 - a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
 - b. Duct systems are complete with terminals installed.
 - c. Volume, smoke, and fire dampers are open and functional.
 - d. Clean filters are installed.
 - e. Fans are operating, free of vibration, and rotating in correct direction.
 - f. Variable-frequency controllers' startup is complete and safeties are verified.
 - g. Automatic temperature-control systems are operational.
 - h. Ceilings are installed.
 - i. Windows and doors are installed.
 - j. Suitable access to balancing devices and equipment is provided.
 2. Hydronics:
 - a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
 - b. Piping is complete with terminals installed.
 - c. Water treatment is complete.
 - d. Systems are flushed, filled, and air purged.
 - e. Strainers are pulled and cleaned.
 - f. Control valves are functioning per the sequence of operation.
 - g. Shutoff and balance valves have been verified to be 100 percent open.
 - h. Pumps are started and proper rotation is verified.
 - i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
 - j. Variable-frequency controllers' startup is complete and safeties are verified.
 - k. Suitable access to balancing devices and equipment is provided.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance"; ASHRAE 111; NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"; SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing"; and in this Section.
- B. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" ASHRAE 111 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
- C. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

- D. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 3300 "Air Duct Accessories."
 - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 0700 "HVAC Insulation."
- E. Mark equipment and balancing devices, including damper-control positions, valve position indicators, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- F. 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.
- G. Take and report testing and balancing measurements in inch-pound (IP) units.
- H. Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 23 3113 "Metal Ducts."

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 - 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 - 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 - 4. Obtain approval from Engineer, Construction Manager, and commissioning authority for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 - 5. Obtain approval from Architect, Owner, Construction Manager, and commissioning authority 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.
 - 6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
 - 1. Measure airflow of submain and branch ducts.
 - 2. Adjust submain and branch duct volume dampers for specified airflow.
 - 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
 - 1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 - 2. Measure inlets and outlets airflow.
 - 3. Adjust each inlet and outlet for specified airflow.
 - 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.

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

3.7 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Single Zone Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance systems similar to constant-volume air systems.
 2. Set air inlets, air outlets, and supply fan at full-airflow condition.
 3. Adjust air outlets to indicated airflow.
 4. Readjust fan airflow for final maximum readings.
 5. Measure operating static pressure at the sensor that controls the supply fan and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
- B. Adjust the variable-air-volume systems as follows:
1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
 2. Verify that the system is under static pressure control.
 3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.

- e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
- 5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
 - c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- 6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
- 7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
- 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
- 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.8 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.
- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
 - 1. Check liquid level in expansion tank.
 - 2. Check highest vent for adequate pressure.
 - 3. Check flow-control valves for proper position.
 - 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 - 5. Verify that motor starters are equipped with properly sized thermal protection.
 - 6. Check that air has been purged from the system.

3.9 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design gpm.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.

3.10 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals, and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
 - 1. Verify that the differential-pressure sensor is located as indicated.
 - 2. Determine whether there is diversity in the system.
- C. For systems with diversity:
 - 1. Determine diversity factor.
 - 2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.

3. Adjust pumps to deliver total design gpm.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
6. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure, and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
7. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
9. Prior to verifying final system conditions, determine system differential-pressure set point.
10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
11. Mark final settings and verify that memory stops have been set.
12. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.

- c. Mark final settings.

- 13. Verify that memory stops have been set.

3.11 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.

3.12 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator and condenser to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
 - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 - 4. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
 - 5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
 - 6. Capacity: Calculate in tons of cooling.
 - 7. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.13 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.14 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

3.15 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 gpm) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

B. 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. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.16 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

A. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.

1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.

- B. After balancing is complete, do the following:
 - 1. Measure and record the static pressure at the hood exhaust-duct connection.
 - 2. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
 - 3. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.
- C. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.
 - 1. Check duct slopes as required.
 - 2. Verify that duct access is installed as required.
 - 3. Verify that point of termination is as required.
 - 4. Verify that duct air velocity is within the range required.
 - 5. Verify that duct is within a fire-rated enclosure.
- D. Report deficiencies.

3.17 PROCEDURES FOR EXHAUST HOODS

- A. Measure, adjust, and record the airflow of each exhaust hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.
- B. After balancing is complete, do the following:
 - 1. Measure and record the static pressure at the hood exhaust-duct connection.
 - 2. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.

3.18 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

- A. After revisions are complete, measure all the HVAC air and water systems modified and restore the systems to their original or scheduled capacities.
 - 1. Compare the indicated flow rates of the renovated work to the measured flow rates and determine the new equipment flow rates.
 - 2. Verify that the indicated flows of the renovated work result in conditions that are within the acceptable limits defined by equipment manufacturer.
 - 3. Re-measure, record and verify the flow rates at interconnection points between existing and new work.
 - 4. If calculations increase or decrease the flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.
 - 5. Balance each affect branch and main.

3.19 TOLERANCES

- A. Set HVAC system's flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent.
 - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
 - 4. Cooling-Water Flow Rate: Plus or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.20 PROGRESS REPORTING

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

3.21 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. Equipment operating curves.
 - 2. Pump curves.
 - 3. Fan curves.
 - 4. Manufacturers' test data.
 - 5. Field test reports prepared by system and equipment installers.
 - 6. Other information relative to equipment performance; do not include Shop Drawings and Product Data.
- C. General Report Data: In addition to form titles and entries, include the following data:
 - 1. Title page.
 - 2. Name and address of the TAB specialist.
 - 3. Project name.
 - 4. Project location.
 - 5. Architect's name and address.
 - 6. Engineer's name and address.
 - 7. Contractor's name and address.
 - 8. Report date.
 - 9. Signature of TAB supervisor who certifies the report.

10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water flow rates.
 3. Water flow rates.
 4. Duct, outlet, and inlet sizes.
 5. Pipe and valve sizes and locations.
 6. Terminal units.
 7. Balancing stations.
 8. Position of balancing devices.
- E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
 - l. Variable frequency drive information.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.

- c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave and amount of adjustments in inches.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat-coil static-pressure differential in inches wg.
 - g. Cooling-coil static-pressure differential in inches wg.
 - h. Heating-coil static-pressure differential in inches wg.
 - i. Outdoor airflow in cfm.
 - j. Return airflow in cfm.
 - k. Outdoor-air damper position.
 - l. Return-air damper position.
 - m. Variable frequency drive information.
- F. Apparatus-Coil Test Reports:
 - 1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft..
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.
- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and amount of adjustments in inches.
 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
 - f. Variable frequency drive setpoint.
- H. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.

- f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft..
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
 - 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.
 - c. Leaving-water temperature in deg F.
 - d. Water pressure drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- K. Packaged Chiller Reports:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Make and model number.
 - c. Manufacturer's serial number.
 - d. Refrigerant type and capacity in gal..
 - e. Starter type and size.
 - f. Starter thermal protection size.
 - g. Compressor make and model number.
 - h. Compressor manufacturer's serial number.
 - 2. Water-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.

3. Air-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering- and leaving-air temperature in deg F.
4. Evaporator Test Reports (Indicated and Actual Values):
 - a. Refrigerant pressure in psig.
 - b. Refrigerant temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Entering-water pressure in feet of head or psig.
 - f. Water pressure differential in feet of head or psig.
5. Compressor Test Data (Indicated and Actual Values):
 - a. Suction pressure in psig.
 - b. Suction temperature in deg F.
 - c. Discharge pressure in psig.
 - d. Discharge temperature in deg F.
 - e. Oil pressure in psig.
 - f. Oil temperature in deg F.
 - g. Voltage at each connection.
 - h. Amperage for each phase.
 - i. Kilowatt input.
 - j. Crankcase heater kilowatt.
 - k. Chilled-water control set point in deg F.
 - l. Condenser-water control set point in deg F.
 - m. Refrigerant low-pressure-cutoff set point in psig.
 - n. Refrigerant high-pressure-cutoff set point in psig.
6. Refrigerant Test Data (Indicated and Actual Values):
 - a. Oil level.
 - b. Refrigerant level.
 - c. Relief valve setting in psig.
 - d. Unloader set points in psig.
 - e. Percentage of cylinders unloaded.
 - f. Bearing temperatures in deg F.
 - g. Vane position.
 - h. Low-temperature-cutoff set point in deg F.
- L. Compressor and Condenser Reports: For refrigerant side of air-cooled condensing units, include the following:
 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Unit make and model number.
 - d. Compressor make.
 - e. Compressor model and serial numbers.
 - f. Refrigerant weight in lb.
 - g. Low ambient temperature cutoff in deg F.

2. Test Data (Indicated and Actual Values):
 - a. Inlet-duct static pressure in inches wg.
 - b. Outlet-duct static pressure in inches wg.
 - c. Entering-air, dry-bulb temperature in deg F.
 - d. Leaving-air, dry-bulb temperature in deg F.
 - e. Condenser entering-water temperature in deg F.
 - f. Condenser leaving-water temperature in deg F.
 - g. Condenser-water temperature differential in deg F.
 - h. Condenser entering-water pressure in feet of head or psig.
 - i. Condenser leaving-water pressure in feet of head or psig.
 - j. Condenser-water pressure differential in feet of head or psig.
 - k. Control settings.
 - l. Unloader set points.
 - m. Low-pressure-cutout set point in psig.
 - n. High-pressure-cutout set point in psig.
 - o. Suction pressure in psig.
 - p. Suction temperature in deg F.
 - q. Condenser refrigerant pressure in psig.
 - r. Condenser refrigerant temperature in deg F.
 - s. Oil pressure in psig.
 - t. Oil temperature in deg F.
 - u. Voltage at each connection.
 - v. Amperage for each phase.
 - w. Kilowatt input.
 - x. Crankcase heater kilowatt.
 - y. Number of fans.
 - z. Condenser fan rpm.
 - aa. Condenser fan airflow rate in cfm.
 - bb. Condenser fan motor make, frame size, rpm, and horsepower.
 - cc. Condenser fan motor voltage at each connection.
 - dd. Condenser fan motor amperage for each phase.
- M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.

- p. Seal type.
 - q. Variable frequency drive information.
2. Test Data (Indicated and Actual Values):
- a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
 - l. Variable frequency drive setpoint.

N. Boiler Test Reports:

1. Unit Data:
- a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and type.
 - e. Model and serial numbers.
 - f. Fuel type and input in Btuh.
 - g. Number of passes.
 - h. Ignition type.
 - i. Burner-control types.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
2. Test Data (Indicated and Actual Values):
- a. Operating pressure in psig.
 - b. Operating temperature in deg F.
 - c. Entering-water temperature in deg F.
 - d. Leaving-water temperature in deg F.
 - e. Number of safety valves and sizes in NPS.
 - f. Safety valve settings in psig.
 - g. High-limit setting in psig.
 - h. Operating-control setting.
 - i. High-fire set point.
 - j. Low-fire set point.
 - k. Voltage at each connection.
 - l. Amperage for each phase.
 - m. Draft fan voltage at each connection.
 - n. Draft fan amperage for each phase.
 - o. Manifold pressure in psig.

O. Instrument Calibration Reports:

1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.22 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of Engineer and commissioning authority.
- B. Engineer and commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- 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 testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, 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.
 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
 3. If the second verification also fails, design professional may contact AABC Headquarters regarding the AABC National Performance Guaranty.
- F. Prepare test and inspection reports.

END OF SECTION 23 0593

SECTION 23 0700 - HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes insulation materials for HVAC systems.
- B. Related Sections:
 - 1. Division 22 Section "Plumbing Insulation."
 - 2. Division 23 Section "Metal Ducts" for duct liners.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated below:
 - 1. Mineral fiber.
 - 2. Flexible elastomeric.
 - 3. Field installed jackets

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program.
- B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.5 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application.

1. Establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.6 SCHEDULING

- A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- E. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
- F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1.
 2. [Provide ASJ or FSK for ductwork applications, as scheduled.]
- H. Mineral-Fiber, Preformed Pipe Insulation:
 1. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ or ASJ-SSL jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral-Fiber, Pipe, Duct and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 1. Provide ASJ for equipment applications.
 - 2.

2.2 INSULATING CEMENTS

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

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

2.5 SEALANTS

- A. Joint Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Permanently flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 100 to plus 300 deg F.
 - 4. Color: White or gray.
 - 5. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. FSK Jacket Flashing Sealants:

1. Products:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.

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

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: White.

2.6 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Adhesive: As recommended by jacket material manufacturer.
2. Color: White.
3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, traps, and mechanical joints.

C. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.

1. Factory cut and rolled to size or sheet and roll stock ready for shop or field sizing.
2. Finish and thickness are indicated in field-applied jacket schedules.
3. Factory-Fabricated Fitting Covers:

- a. Same material, finish, and thickness as jacket.
- b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
- c. Tee covers.
- d. Flange and union covers.
- e. End caps.
- f. Beveled collars.
- g. Valve covers.
- h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 11.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 6.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 1. Width: 2 inches.
 2. Thickness: 6 mils.
 3. Adhesion: 64 ounces force/inch in width.
 4. Elongation: 500 percent.
 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 1. Width: 2 inches.
 2. Thickness: 3.7 mils.
 3. Adhesion: 100 ounces force/inch in width.
 4. Elongation: 5 percent.
 5. Tensile Strength: 34 lbf/inch in width.

2.9 SECUREMENTS

- A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch or 3/4 inch wide with wing or closed seal.
- B. Insulation Pins and Hangers:
 - 1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel; fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 - 3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, aluminum, or stainless steel; fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
 - 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel, aluminum, or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

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

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations:
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation at roof structure and seal with joint sealant.
 3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 4. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 5. 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.
 - 3. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 4. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 5. 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. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
 - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
 - 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 - 2. Pipe: Install insulation continuously through floor penetrations.
 - 3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

- A. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of tank and vessel surfaces.
 - 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 - 3. Protect exposed corners with secured corner angles.
 - 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
 - d. Do not overcompress insulation during installation.

- e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches.
 8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.
- C. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 2. Fabricate boxes from galvanized steel or aluminum, at least 0.050 inch thick.
 3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.6 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For mineral fiber insulation, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. 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. Insulation Installation on Control Valves:
1. Omit insulation over control valves.
- 3.7 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION
- A. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
1. Flexible elastomeric pipe insulation only allowed in concealed or mechanical room locations.
- B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 FIELD-APPLIED JACKET INSTALLATION

- A.** Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturers 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.
2. Fill inside of fitting jackets to prevent collapse of jacket.

3.9 FINISHES

- A.** Paintable Jacket Material: Paint jacket with paint system identified in Division 09 painting Sections.

3.10 DUCT INSULATION SCHEDULE, GENERAL

- A.** Plenums and Ducts Requiring Insulation: Insulate the following in accordance with insulation schedule:

1. Supply air.
2. Outdoor air.
3. Return air.
4. Relief air.
5. Exhaust air.
6. Slot and linear diffuser plenums.

B. Items Not Insulated:

1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings, except as indicated.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.
6. Exposed supply and return metal ducts within rooms they are serving except mechanical rooms.
7. Exposed supply metal ducts within rooms they are serving down stream of fan coils and VAV terminal units except mechanical rooms.
8. Volume control balancing damper lever handles.

C. Definitions:

1. Concealed: Above solid ceiling and not visible from below.
2. Exposed: In rooms with no ceilings or with partial ceilings (i.e. "cloud type ceilings") and visible from below.
3. Finished Spaces: Spaces with room finishes accessible by building occupants.
4. Unfinished Spaces: Spaces with no or limited room finishes accessible by building maintenance and support staff only.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. supply and return air duct and plenum insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.

B. supply and return air duct and plenum insulation shall be the following:

1. Mineral-Fiber Board with ASJ: 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.

C. insulation shall be the following:

1. Mineral-Fiber Board with FSK Jacket: 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.

D. supply and exhaust air duct and plenum insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.

E. supply and exhaust air duct and plenum insulation shall be the following:

1. Mineral-Fiber Board with: 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.

F. insulation shall be the following:

1. Mineral-Fiber Board with FSK Jacket: 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.

G. Concealed relief, supply and return air duct and plenum insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
 - H. Concealed exhaust-air duct and plenum insulation between isolation damper and penetration of building exterior shall be the following:
 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
 - I. Exposed relief, supply and return air duct insulation within mechanical rooms shall be the following:
 1. Mineral-Fiber Board with FSK Jacket (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
 2. Mineral-Fiber Duct, Pipe and Tank with FSK Jacket (For Round or Flat Oval Duct Applications): 1-1/2 inches thick.
 - J. Exposed exhaust-air duct insulation within mechanical rooms between isolation damper and penetration of building exterior shall be the following:
 1. Mineral-Fiber Board with FSK Jacket (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
 2. Mineral-Fiber Duct, Pipe and Tank with FSK Jacket (For Round Duct Applications): 1-1/2 inches thick.
 - K. Exposed supply air duct insulation exposed in finished spaces shall be the following:
 1. Mineral-Fiber Board with ASJ (For Rectangular Applications): 1-1/2 inches(38 mm) thick and 3-lb/cu. ft.(48-kg/cu. m) nominal density.
 2. Mineral-Fiber Duct, Pipe and Tank with ASJ (For Round or Flat Oval Duct Applications): 1-1/2 inches thick.
 - L. Exposed outside, relief, supply and return air duct insulation within mechanical rooms shall be the following:
 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
 - M. Exposed exhaust-air duct insulation within mechanical rooms between isolation damper and penetration of building exterior or becomes concealed shall be the following:
 1. Mineral-Fiber Blanket: 1-1/2 inches(38 mm) thick and 0.75-lb/cu. ft.(12-kg/cu. m) nominal density.
- 3.12 EQUIPMENT INSULATION SCHEDULE
- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
 - B. Insulate equipment in paragraphs below that are not factory insulated.
 - C. Heating-hot-water air-separator insulation shall be the following:
 1. Mineral-Fiber Pipe and Tank with ASJ: 2 inches thick.

3.13 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable insulation materials and thicknesses are identified for each piping system and pipe size range.
 - 1. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Control valve stem and actuator.

3.14 INDOOR PIPING INSULATION SCHEDULE

- 1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
- 2. Flexible Elastomeric: 1 inch thick.
- B. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):
 - 1. All Pipe Sizes Exposed in Mechanical Rooms and Concealed Locations: Insulation shall be one of the following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
 - 2. All Pipe Sizes Exposed in Finished Spaces: Insulation shall be following:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch(25 mm) thick.
- C. Chilled Water, above 40 Deg F: Insulation shall be one of the following:
 - 1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
 - 2. Flexible Elastomeric: 1 inch thick.
- D. Heating-Hot-Water Supply and Return, 200 Deg F and below: Insulation shall be the following:
 - 1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick, NPS 3 diameter and under; 1-1/2 inchesthick, over NPS 3 diameter.
- E. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:
 - 1. Mineral-Fiber, Preformed Pipe, Type I: 1 inch thick.
 - 2. Flexible Elastomeric: 1 inch thick.

3.15 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

- A. Chilled Water: Insulation shall be one of the following:
 - 1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick with field applied jacket.
 - 2. Flexible Elastomeric: 2 inches thick with field applied jacket.
- B. Refrigerant Suction and Hot-Gas Piping: Insulation shall be one of the following:
 - 1. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

2. Flexible Elastomeric: 2 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 1. If more than one material is listed, selection from materials listed is Contractor's option.
- B. Pipe Fittings with Mineral Fiber Insulation:
 1. PVC Fitting Covers: 20 mils thick, white.
- C. Exposed Vertical Piping within 8 feet of Floor shall be one of the following:
 1. PVC: 30 mils thick, white.
 2. Aluminum, Smooth or Stucco Embossed: 0.024 inch thick.

END OF SECTION 23 0700

SECTION 23 0800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.
 - 2. Division 22 Section "Commissioning of Plumbing" for plumbing commissioning requirements.
 - 3. Division 26 Section "Commissioning of Electrical" for electrical commissioning requirements.

1.2 ABBREVIATIONS

- A. HVAC&R: Heating, Ventilating, Air Conditioning, and Refrigeration.
- B. Refer to Division 01 Section "General Commissioning Requirements" for additional list of abbreviations used in the Specifications and in the Commissioning Plan.

1.3 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for definitions.

1.4 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

1.5 COMMISSIONING PROCESS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to the commissioning process.

1.6 COMMISSIONING TEAM RESPONSIBILITIES

- A. Provide information requested by the CxA for final commissioning documentation.
 - 1. Test reports
- B. Assist the CxA in all verification and functional performance tests.
- C. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work.

- D. Refer to Division 01 Section "General Commissioning Requirements" for additional requirements pertaining to the contractor responsibilities.

1.7 SYSTEMS TO BE COMMISSIONED

- A. Any HVAC equipment or systems that are monitored and or controlled by Building Management System will be commissioned with no sampling methods.
- B. Refer to Division 01 Section "General Commissioning Requirements" for HVAC systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Refer to Division 01 Section "General Commissioning Requirements" for test equipment requirements.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Refer to Division 01 Section "General Commissioning Requirements" for meeting requirements.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. No commissioning checklists will be required to be completed by Mechanical contractor as noted below:
 - 1. Sheetmetal
 - 2. Piping
- B. Commissioning checklists will be required to be completed by Controls contractor.
- C. Refer to Division 01 Section "General Commissioning Requirements" for additional participation requirements for start-up, prefucntional checklists and initial checkout.

3.3 FUNCTIONAL PERFORMANCE TESTING

- A. Sampling: No sampling of any equipment will be permitted. All equipped or types referenced in Division 01 Section "General Commissioning Requirements" will be 100% sample rate regardless of qty or size of equipment or system.
- B. Refer to Division 01 Section "General Commissioning Requirements" for additional participation requirements for functional performance testing.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.

3.5 DEFERRED TESTING

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

3.6 WRITTEN WORK PRODUCTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to written work products related to the commissioning process.

END OF SECTION 23 0800

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SECTION 23 0900 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Work shall include furnishing all labor, materials, equipment, and service necessary for a complete and operating Building Management System (BMS), utilizing direct digital controls. The BMS shall be capable of total integration of the facility infrastructure systems with user access to all system data either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet. This shall include HVAC control, energy management, and all trending, reporting and maintenance management functions related to normal building operations all as indicated.
 - 1. All labor, material, equipment and software not specifically referred to herein or on the plans, required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
- B. Work shall include but not limited to providing controls and instrumentation in accordance with equipment sequence of operations and their point lists. Point lists shall be a guide to the points required for control system. Final points required shall be determined by sequence of operation requirements.
- C. Work required in this section shall include providing all control components, control wiring, and services required for the connection and operation of the Air Handling Units including related variable frequency drives and VAV terminal unit boxes as indicated on drawings, and as specified in Sections and Section 23 0900.
- D. Work required in this section shall include providing all control components, control wiring, and services required for the connection and operation of the exhaust fans as indicated on drawings, and Section 23 0900.
- E. Work required in this section shall include providing all control components, control wiring, and services required for the connection and operation of the hydronic heating and cooling system and equipment as indicated on drawings and Section 23 0900.
- F. Work required in this section shall include providing all control components, control wiring, and services required for the connection and operation of the IT room air conditioning units not indicated to have factory controls as indicated on drawings, and as specified in Section 23 8126.
- G. Work required in this section shall include providing all control components, control wiring, and services required for the connection and monitoring of the natural gas and electrical services as indicated on drawings and as specified in Sections 01 0123 and 23 0900.
- H. Work required in this section shall include providing all control components, control wiring, and services required for the connection of the remaining equipment as indicated on drawings, as specified in various Division 23 sections, and as specified in Section 23 0900.
- I. Work required in this section shall include the complete Building Management System (BMS) including all controllers Interoperable LonWorks Controllers (ILC), Interoperable BACnet Controllers (IBC), control devices, control panels, controller programming, controller programming software, controller input/output wiring, power wiring, interlock and safety wiring, graphical user interface, Graphical User Interface (GUI),

Graphical Development Tool (GDT), Network Area Controller(s) (NAC), server software, controller software and programming of the NAC and server, development of all graphical screens, setup of schedules, logs and alarms, global server software control applications, system integration and coordination of the NAC and server software to the Wide Area Network.

- J. Ethernet LAN wiring, and Ethernet routing devices if applicable. The BMS shall provide a single point Ethernet connection utilizing OBIX TCP/IP to the Owner's WAN.
- K. Work required in this section shall include providing all electrical work required for this section. The system shall include all interconnecting wiring and conduit as required for a fully operational system as specified. Wiring shall be installed as per local codes or Division 26 whichever is more stringent.
 - 1. Power supply wiring and conduit from power source to power connection on DDC controls and DDC control panels.
 - a. Line voltage wiring shall utilize methods and materials complying with the requirements of the Electrical Specifications, local building code, and NEC.
 - 2. Control wiring and conduit between field-installed controls, indicating devices, and control panels.
 - a. Low voltage wiring shall use methods and materials complying with the requirements of the Electrical Specifications, local building code and NEC. Plenum rated cable is acceptable where concealed and accessible.

1.2 RELATED SECTIONS

- A. The following Sections contain requirements that relate to this Section:
 - 1. Division 23 Section "Common Work Results for HVAC."
 - 2. Division 23 Section "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.3 WORK BY OTHERS

- A. Setting in place of valves, flow meters, water pressure and differential taps, flow switches, thermal wells, dampers, airflow stations, and access doors.
- B. Duct smoke detectors provide under Division 28.

1.4 ACTION SUBMITTALS

- A. Refer to Division 1 for submittal administrative requirements and procedures.
- B. Submittal shall consist of:
 - 1. System architecture showing all digital devices, computers and network configuration.
 - 2. Equipment lists of all proposed devices and equipment including data sheets of all products. Provide a PIC statement for each BACnet device and interoperability certification for each LonMark field device provided.
 - 3. Valve, damper, and well and tap schedules showing size, configuration, capacity and location of all equipment.

4. Data entry forms for initial parameters. Contractor shall provide English listing of all analog points with columnar blanks for high and low warning limits and high and low alarm limits, and a listing of all systems with columnar blanks for beginning and end of occupancy periods; and samples of proposed text for points and messages (for at least two systems of at least 15 points total) including sample 480 character alarm message. All text shall be approved prior to data entry.
5. Schematic device wiring and piping interconnection diagrams including panel and device power and sources.
6. Software design data including flowchart of a typical DDC program showing interrelationship between inputs, PID functions, all other functions, outputs, etc.
7. A complete written Sequence of Operation in suppliers own terminology.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data for control systems equipment to include in the operation and maintenance manual specified in Division 1. Include the following:
 1. Maintenance instructions and spare parts lists for each type of control device.
 2. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 3. Calibration records and list of set points.
- B. Project Record Documents: Upon completion of the work, provide a complete set of 'as-built' drawings and application software on USB drive media or compact disk. Drawings shall be provided as AutoCAD™ or Visio™ compatible files. Three copies of the 'as-built' drawings shall be provided in addition to the documents on USB drive media or compact disk.

1.6 CODES AND APPROVALS

- A. The complete BMS installation shall be in strict compliance to the national, state and local mechanical and electrical codes and the electrical section of these specifications. All devices shall be UL or FM listed and labeled for the specific use, application and environment to which they are applied.
- B. The system shall comply with NFPA 90A Air Conditioning and 90B Warm Air Heating, Air conditioning.
- C. All electronic equipment shall conform to the requirements of FCC regulation Part 15, Section 15 governing radio frequency electromagnetic interference and be so labeled.

1.7 WARRANTY

- A. All components, system software, and parts supplied by the BMS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date. The BMS contractor at no charge shall furnish labor to repair, reprogram, or replace components during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the Owners request for warranty service within 48 hours during normal business hours.
- B. Warranty Access
 1. The Owner shall grant to the controls installer reasonable access to the BMS during the warranty period.

1.8 BMS CONTRACTOR QUALIFICATIONS

- A. The BMS contractor shall have a local office within a 75 mile(120 Km)radius of the job site, staffed with factory trained engineers fully capable of providing instruction, routine maintenance and 24-hour emergency service on all system components. The BMS contractor shall have a three year experience record in the design and installation of computerized building systems similar in scope and performance to that specified herein, and shall be prepared to provide evidence of this history as condition of acceptance and approval during Submittal.

1.9 SOFTWARE LICENSE AGREEMENT

- A. Software licensing for the NAC and server software shall give the Owner the capability to control their system and determine which contractors can bid and engineer their system.
- B. It shall be possible to insure the Owner can prevent unauthorized partners from accessing the system for engineering changes.
- C. Software licensing shall have the freedom to individually manage authorized parties and independent parties.
- D. The software licensing shall have no restrictions on which brand of NAC, server software or System Programming tools can interact with the system. Station Compatibility IN and Station Compatibility OUT must = ALL and Tool Compatibility must = ALL.
- E. The Owner shall accept the manufacturer's standard software and firmware licensing agreement as a condition of this contract. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.

1.10 ADDED POINT AND MEMORY CAPACITY

- A. The BMS software/firmware provided shall have the capacity for an unlimited number of NACs. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.
- B. Total system point capacity shall have the capacity for an unlimited number of future points. Systems requiring future upgrades to accomplish this are not acceptable; capacity shall be provided at the time of bid.
- C. Supervising software shall allow unlimited expansion. Supervising software that is limited to the number of network area controllers is not acceptable

1.11 TESTING AND BALANCING

- A. If proper sequencing or system functions cannot be achieved with the controls, as installed, and additional controls are required, the required additional controls shall be added at the expense of the Controls provider.

1.12 DELIVERY, STORAGE, AND PROTECTION

- A. Store equipment and materials inside and protected from weather.
- B. Factory-Mounted Components: Arrange for shipping control devices to terminal unit manufacturer for factory mounting on equipment,

1.13 COORDINATION

- A. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.
- B. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Acceptable Manufacturer: Tridium Niagara Framework version N4, Honeywell WEBs N4, Honeywell Spyder, Honeywell Stryker and Smart Controls fully programmable controllers.
- B. Closed, proprietary or systems not made available to the open market and their products are not acceptable.
- C. Requests for substitutions will be considered in accordance with provisions of Division 1 Section "Product Requirements".

2.2 INSTALLERS

- A. Subject to compliance with requirements, provide installation, products and services by the following:
 - 1. ControlNet LLC.

2.3 GENERAL

- A. The Building Management System (BMS) shall be comprised of a network of interoperable, stand-alone digital controllers, Network Area Controllers, server software server, graphical user interface software, Web Browser Clients, operator work stations , portable operator terminals , printers, network devices and other devices as specified herein.
- B. Provide the capability to open all control valves in each individual system at one time (I.E. zone, riser) to facilitate water balancing.
- C. The controllers and devices shall use either the Echelon® LONMARK® or BACnet™ protocol for openness and interoperability. The controllers and devices shall be 100% programmable and configurable. No additional configuration tools shall be required to edit, re-program, or access the

Echelon® LONMARK® or BACnet™ controllers. Controllers requiring a separate configuration tool for these functions are not acceptable.

2.4 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

- A. The requirement of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate SNMP, LonWorks, BACnet IP, BACnet MSTP, Modbus TCP/IP or Modbus RTU communication protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI / ASHRAE™ Standard 135, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide an XIF file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet. For each Modbus device supplier must provide a Registry of data points available on the system.
- C. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
- D. The supplied system must incorporate the ability to access all data using standard web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. The installed system shall provide secure password access to all features, functions and data contained in the overall BMS. Secure Socket Layer (SSL) encryption shall be an available option for remote access.
- F. The installed system must be totally scalable to allow for future expansion with the addition of controllers and/or input/output devices. It shall not be necessary to remove equipment supplied under this contract to expand the system.
- G. The failure of any single component or network shall not interrupt the control functions of non-affected devices. A single network failure shall only affect shared communications or shared data; individual application controllers and network controllers shall continue normal operation minus only the data from a remote device from the affected network. Automatic default values for all network transported data shall be provided to allow continued operation until the network is restored.
- H. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
 - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
 - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.5 NETWORK AREA CONTROLLER (NAC)

- A. The controls Installer shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of area controllers required is dependent on the type and quantity of devices.
- B. The Network Area Controller (NAC) shall provide the interface between the ILC, IBC and the Network server software, and provide global supervisory control functions over the control devices connected to the BMS. It shall be capable of executing application control programs to provide:
 - 1. Calendar functions
 - 2. Scheduling
 - 3. Trending
 - 4. Alarm monitoring and routing
 - 5. Time synchronization
 - 6. Integration of LonWorks controller data, Modbus controller data and BACnet controller data
 - 7. Network Management functions for all LonWorks based devices
- C. The Network Area Controller must provide the following hardware features as a minimum:
 - 1. Two Isolated Ethernet Ports – 10/100 Mbps
 - 2. One RS-232 port
 - 3. One RS-485 port
 - 4. One LonWorks Interface Port – 78KB FTT-10A
 - 5. Battery Backup
 - 6. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 10 gigabyte storage capacity)
 - 7. The NAC must be capable of operation over a temperature range of 32 to 130 deg F
 - 8. The NAC must be capable of withstanding storage temperatures of between 32 to 158 deg F
 - 9. The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing
- D. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 10 simultaneous users.
- E. Event Alarm Notification and actions
 - 1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 - 2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up telephone connection, or wide-area network.
 - 3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to:
 - a. To alarm
 - b. Return to normal
 - c. To fault
 - 4. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
 - 5. Provide timed (schedule) routing of alarms by class, object, group, or node.
 - 6. Provide alarm generation from binary object “runtime” and for event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

7. Control equipment and network failures shall be treated as alarms and annunciated.
8. Alarms shall be annunciated in any of the following manners as defined by the user:
 - a. Screen message text
 - b. Text or email of the complete alarm message to multiple recipients. Provide the ability to route and send alarms based on:
 - 1) Day of week
 - 2) Time of day
 - 3) Recipient
9. Graphic with flashing alarm object(s)
10. Printed message, routed directly to a dedicated alarm printer
11. The following shall be recorded by the NAC for each alarm (at a minimum):
 - a. Time and date
 - b. Location (building, floor, zone, office number, etc.)
 - c. Equipment (air handler #, access way, etc.)
 - d. Acknowledge time, date, and user who issued acknowledgement.
 - e. Number of occurrences since last acknowledgement.
12. Alarm actions may be initiated by user defined programmable objects created for that purpose.
13. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
14. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.
15. Provide a "query" feature to allow review of specific alarms by user defined parameters.
16. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
17. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

F. Data Collection and Storage

1. The NAC shall have the ability to collect data for any object and store this data for future use.
2. The data collection shall be performed by log objects, resident in the NAC that shall have, at a minimum, the following configurable properties:
3. Designating the log as interval or deviation.
4. For interval logs, the object shall be configured for time of day, day of week and the sample collection interval.
5. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
6. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
7. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
8. All log data shall be stored in a relational database and the data shall be accessed from a standard Web Browser.
9. All log data, when accessed from the Network server software (NS), shall be capable of being manipulated using standard SQL statements.
10. All log data shall be available to the user in the following data formats:
 - a. HTML
 - b. XML
 - c. Plain Text

- d. Comma or tab separated values
- 11. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
- 12. The NAC shall have the ability to archive its log data to Network server software on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - a. Archive on time of day
 - b. Archive on user-defined number of data stores in the log (buffer size)
 - c. Archive when log has reached it's user-defined capacity of data stores
 - d. Provide ability to clear logs once archived
- G. Audit Logs
 - 1. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive the log based on time to the Network server software. For each log entry, provide the following data:
 - a. Time and date
 - b. User ID
 - c. Change or activity: i.e., Change set-point, add or delete objects, commands, etc.
- H. Database Back-Up and Storage
 - 1. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
 - 2. Copies of the current database and, at the most recently saved database shall be stored on the Network server software. The age of the most recently saved database is dependent on the user-defined database save interval.
 - 3. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2.6 INTEROPERABLE LON CONTROLLER (ILC)

- A. Controls shall be microprocessor based Interoperable LonMark™ or LonWorks Controllers (ILC). Where possible, all Interoperable LonWorks Controllers shall bear the applicable LonMark™ interoperability logo on each product delivered.
- B. HVAC control shall be accomplished using LonMark™ based devices where the application has a LonMark profile defined. Where LonMark devices are not available for a particular application, devices based on LonWorks shall be acceptable. Publicly available specifications for the Applications Programming Interface (API) must be provided to Owner for each LonWorks / LonMark controller defining the programming or setup of each device. The controls Installer shall provide all programming, documentation and programming tools necessary to set up and configure the supplied devices per the specified sequences of operation.
- C. The controls Installer shall run the LonWorks network trunk to the nearest Network Area Controller (NAC). Coordinate locations of the NAC with the LonMark devices to ensure that maximum network wiring distances, as specified by the LonWorks wiring guidelines, are not exceeded. A maximum of 126 devices may occupy any one LonWorks trunk and must be installed using the appropriate trunk termination device. All LonWorks and LonMark devices must be supplied using FTT-10A LonWorks communications transceivers.

- D. The Network Area Controller (NAC), will provide all scheduling, alarming, trending, and network management for the LonMark / LonWorks based devices.
- E. The ILCs shall communicate with the NAC at a baud rate of not less than 78.8K baud. The ILC shall provide LED indication of communication and controller performance to the technician, without cover removal.
- F. All ILCs shall be fully application programmable and shall at all times maintain their LONMARK certification, if so certified. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the ILC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
- G. The controls Installer shall provide documentation for each device, with the following information at a minimum:
 - 1. Network Variable Inputs (nvi's); name and type
 - 2. Network Variable Outputs (nvo's); name and type
 - 3. Network configuration parameters (nci, nco); name and type
- H. It is the responsibility of the controls Installer to ensure that the proper Network Variable Inputs and Outputs (nvi and nvo) are provided in each ILC, as required by the point charts.
- I. The controls Installer of any programmable ILC shall provide one copy of the manufacturer's programming tool, with documentation, to the Owner.

2.7 INTEROPERABLE BACnet CONTROLLER (IBC)

- A. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the ANSI/ASHRAE Standard 135-1995. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-1995, to Owner.
- B. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps or via the RS485 connection at a baud rate of not less than 38 kbps.
- C. The IBC Sensor shall connect directly to the IBC and shall not utilize any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
- D. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.

- E. The controls Installer shall provide documentation for each device, with the following information at a minimum:
 - 1. BACnet Device; MAC address, name, type and instance number
 - 2. BACnet Objects; name, type and instance number
- F. Ensure that the proper BACnet objects are provided in each IBC, as required by the point charts.

2.8 NETWORKS

- A. The Local Area Network (LAN) shall be a 100 Megabits/sec Ethernet network supporting TCP/IP, BACnet IP, Modbus, Java, XML, and HTTP for maximum flexibility for integration of building data with enterprise information systems
- B. Local area network minimum physical and media access requirements:
 - 1. Ethernet; IEEE standard 802.3
 - 2. Cable; 10 Base-T, UTP-8 wire, category 5E or 6
 - 3. Minimum throughput; 10 Mbps, with ability to increase to 100 Mbps

2.9 NETWORK ACCESS

- A. Owners WAN / LAN Access: Controls Installer must adhere to Owner's policy and requirements to obtain Owner's WAN access.

2.10 GRAPHICAL USER INTERFACE (GUI)

- A. The graphical component of the BMS is of critical importance and should consider the following descriptions and graphic representations to be the minimum acceptable. Enhanced graphics shall include detailed 2-dimensional building site and floor plan graphics, 3-dimensional equipment graphics with fan, damper and valve animations providing operators an aid to comprehending complex system operation. Every graphic page shall contain a tabular and cascading menu navigational structure, established in an HTML frame based format to allow immediate "one-click" access to other building systems without the need to back up through the navigational tree.
- B. Navigation is done through the use of an HTML-based menu bar. The contents of the menu bar shall be customized to match the specific requirements of each building, while retaining the same general categories for consistency and familiarity.
 - 1. The menu bar shall employ cascading menus. With this navigation concept, the operator shall not be more than two mouse button operations from any view. Some examples of the operator screens follow.
 - 2. Displays shall provide real-time information with visual display of alarm condition by change of color and/or flashing text/color background.
 - 3. Displays can be viewed from a non-proprietary, commercial Web Browser.
 - 4. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, will be setup such that an operator, by right-clicking the data object or graphic, will be able to command a digital value, or modify an analog value. Operators shall view equipment status from the menu. Menu items shall include headings for major equipment categories such as Air

- Handling Units, Boiler, Chillers, Zone Control, Lighting, etc. Cascading menus from each major category, shall allow the operator to select a particular piece of equipment; i.e. AHU-1 or Chiller.
5. A maximum of 40 points will be provided in a single status display screen. Points that have been defined as data-writes, either as a digital (on/off) or analog (change value) point type, shall be setup such that an operator, by right-clicking the data object or graphic, shall be able to command a digital value, or modify an analog value.

- C. All Graphics and schedules will reside at the supervisory software level and not at the NAC level to allow for "one password" access to all NACs on the system and global scheduling and trending.

2.11 CUSTOM GRAPHICS - REQUIRED

A. Home Page

1. The building site overview shall provide a "mouse over" function to highlight the floor plan area to be accessed as a navigational aid. Room numbers and/or names will be included at the owner's request. Critical data points, i.e. Outdoor Air Temperature, Outdoor Air Relative Humidity, Hot Water Supply Temperature, Chilled Water Supply Temperature or National Weather Service data will be continuously visible, in real time, within the HTML frame on all screens. Additional points may be added or deleted at the owner's request without cost.

B. Floor Plans

1. Detailed floor plans shall be created with a vector drawing program accurately depicting the actual building layout to include all rooms, walls, and hallways. All space sensors shall be accurately placed in their actual locations and tagged with their real time space temperature and equipment each is associated with, i.e. 72.5°F/RTU-1, 74.2°/AHU-1, 73.4°/TU-1. Floor plans too large to be practically shown with data points will provide a "mouse over" function to highlight the floor plan area to be accessed. Room numbers and/or names will be included at the owner's request.

C. Mechanical Systems

1. Detailed graphics for each mechanical system shall include; AHUs, RTUs, HXs, CW Piping and Pumps, HW Piping and Pumps, HPs, TUs, and EFs as a minimum. Mechanical systems shall include on-screen access to their respective set-points, trend logs and schedule. All time schedules will be setup as directed by the owner prior to final job turnover.
2. Dynamic trends of all data points shall be set up (specification will be followed as to actual number of trend points possible) prior to final job turnover. Each trend will be available directly on screen for quick trend access.
3. Data points will be shown for all relevant inputs and outputs and be positioned near the actual device. Analog and digital parameters will be able to be modified directly from the equipment screen.

D. Terminal Units

1. Terminal units such as fan coil units, reheat coils, booster coils and VAV boxes will depict the actual configuration of the equipment controlled. Actual equipment configurations from manufacturers web sites and/or photos of installed equipment shall be used to ensure graphic depictions are as "near actual" as possible.

E. Schedules

1. Graphical schedules shall allow the operator to adjust time of day schedules by dragging the On Event slider. An unlimited number of On/Off events shall be allowed for each schedule and schedules can be linked into a Master/Slave scheduling scheme. Schedules shall allow the user to add/edit/delete holiday and special event schedules. Schedules shall be included for each major piece of equipment.

F. Logging

1. Logs shall be provided for all points defined as requiring collection and archiving of their real-time values. Log data will be provided in HTML, XML, comma- and tab-separated value, and plain-text formats.
 - a. Coordinate with Owner and Engineer for required points for logging.
 - b. Each of the following of point types shall be continuously trended. The user shall have the ability to select up to 3 points to be displayed on a single trending graph.
 - 1) All Temperatures
 - 2) All Temperature setpoints
 - 3) All Damper Positions
 - 4) All Valve Positions
 - 5) All VFD %
 - 6) All Airflows
 - 7) All Occupancy statuses
 - 8) All Enthalpies
 - 9) All Humidity's
 - 10) All CO2s
2. Setup parameters for each log include; log intervals, number of collection samples, log collection times and archive times, delta logging with change value selection, etc.
3. For every log, the data shall be viewable in both tabular and chart formats.
4. Logs shall be archived to the server software daily at a user specified time of day. Archive data shall be available from the creation time of the log until the last archive time.
5. For every log, the data can be viewed in both tabular and chart formats.
6. Logs and archives will be accessible from a Web Browser (Internet Explorer 5.0 or greater).
7. Analog Logs: Value Collected every 15 minutes for a log total of 2 days.

2.12 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacturer-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BMS, shall not be acceptable.
- C. The Web browser client shall support at a minimum, the following functions:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
2. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
3. Storage of the graphical screens shall be in the NAC or server software, without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
4. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
5. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - 1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - 2) Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 - b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - c. View logs and charts
 - d. View and acknowledge alarms
 - e. Setup and execute SQL queries on log and archive information
6. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
7. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.13 SERVER SOFTWARE FUNCTIONS AND HARDWARE

- A. The server software shall be provided. The server software shall support all TCP/IP connected to the control system router.
- B. The Network server software shall provide the following functions, at a minimum:
 1. Global Data Access: The server software shall provide complete access to distributed data defined anywhere in the system.
 2. Distributed Control: The server software shall provide the ability to execute global control strategies based on control and data objects in any control system in the network, local or remote.
 3. The server software shall include a master clock service for its subsystems and provide time synchronization for all control systems.
 4. The server software shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
 5. The server software shall provide scheduling for all control systems and their underlying field control devices.

6. The server software shall provide demand limiting that operates across all control systems. The server software must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
7. The server software shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to control systems. Systems not employing this prioritization shall not be accepted.
8. Each control system supported by the server software shall have the ability to archive its log data, alarm data and database to the Network server software, automatically. Archiving options shall be user-defined including archive time and archive frequency.
9. The server software shall provide central alarm management for all control systems supported by the server software. Alarm management shall include:
 - a. Routing of alarms to display, printer, email and pagers
 - b. View and acknowledge alarms
 - c. Query alarm logs based on user-defined parameters
10. The server software shall provide central management of log data for all control systems supported by the server software. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:
 - a. Viewing and printing log data
 - b. Exporting log data to other software applications
 - c. Query log data based on user-defined parameters

C. Server software Hardware Requirements: supplied by

1. The system integrator will be responsible for loading and testing the software on the PC.
2. The system integrator will coordinate with the owner for testing and authorization.

2.14 SYSTEM PROGRAMMING

- A. The Graphical Development Tool (GDT) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. The programming toolset will be provided to the owner as part of this project. The programming software shall be the same programming toolset as used by the contractor's engineers when programming this project. Access to the programming functions and features of the GDT shall be through password access as assigned by the system administrator.
- B. The GDT shall be available in two versions; a thick-client version licensed to the computing platform on which it is installed and a thin-client version, capable of providing the complete set of engineering functions through a standard Web Browser. Programming and development tools not capable of providing all engineering and application development functions with a standard Web Browser are not acceptable.
- C. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. All graphics must be created with a vector 3-D imaging software package, i.e.,

Dream Weaver, Illustrator, Cool 3-D or other commercially available graphics package.

D. Programming Methods

1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real-time. Systems requiring the uploading on the owner's IT network, and downloading of database objects shall not be allowed.
5. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.15 OBJECT LIBRARIES

- A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
- B. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
- C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.
- D. All control objects shall conform to the control objects specified in the BACnet specification.
- E. The library shall include applications or objects for the following functions, at a minimum:
 1. Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on-off events.
 2. Calendar Object. . The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.

3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals
 4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
 5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start / stop time object properties based on the previous day's performance.
 6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.
- F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.
1. Analog Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
 2. Analog Output Object - Minimum requirement is to comply with the BACnet standard for data sharing.
 3. Binary Input Object - Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
 4. Binary Output Object - Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.
 5. PID Control Loop Object - Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.

6. Comparison Object - Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
 7. Math Object - Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
 8. Custom Programming Objects - Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.
 9. Interlock Object - Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
 10. Temperature Override Object - Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.
 11. Composite Object - Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.
- G. The object library shall include objects to support the integration of devices connected to the Network Area Controller or server software. At a minimum, provide the following as part of the standard library included with the programming software:
1. LonMark/LonWorks devices. These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. All network variables defined in the LonMark profile shall be supported. Information (type and function) regarding network variables not defined in the LonMark profile shall be provided by the device manufacturer.
 2. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file and documentation for the device to facilitate device integration.
 3. For BACnet devices, provide the following objects at a minimum:
 - a. BACnet AI
 - b. BACnet AO
 - c. BACnet BI

- d. BACnet BO
 - e. BACnet Device
4. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

2.16 OTHER CONTROL SYSTEM HARDWARE

A. Ethernet Switches

- 1. 8 Port 10/100 MBPS Switch / Hub
- 2. Din Rail Mounted
- 3. LED communication indicators
- 4. Acceptable Manufacturers
 - a. Contemporary Controls
 - b. INTEL
 - c. Cisco Systems

B. Temperature Sensors and Transmitters

- 1. General Sensor & Transmitter Requirements
 - a. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, and as required to achieve the specified accuracy as specified herein.
 - b. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
 - c. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearities of the sensor and bridge and provide a true linear output signal.
 - d. Temperature sensors shall be of the resistance type and shall be 10K or 20K Ohm Thermistor type.
 - 1) Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the controllers operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical/expressions. Thermistors shall be of the Thermistor (NTC) Type with a minimum of 50 ohm/°C. resistance change versus temperature to insure good resolution and accuracy.
 - e. The following accuracy's are required and include errors associated with the sensor, lead wire and A to D conversion.
 - 1)

<u>Point Type</u>	<u>Accuracy</u>
Outside Air	+/-3%
Chilled/Hot Water	+/-1%
Room Temperature	+/-1%
+/-5%	
Duct Temperature	+/-3%
 - 2) Sensors Used in Energy Water (BTU) or Process Calculations +/-1%
 - 3) Sensors used in energy or process calculations shall be accurate over the process temperature range. Submit a manufacturer's calibration report indicating that the

calibration certification is traceable to the National Bureau of Standards (NBS)
Calibration Report Nos. 209527/222173.

2. Thermowells
 - a. When thermowells are required, the sensor and well shall be supplied as a complete assembly including well head and Greenfield fitting, except where wells are to be installed under separate contract.
 - b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure
 - c. Thermowells and sensors shall be mounted in a threadolet or 1/2" NPT saddle and allow easy access to the sensor for repair or replacement.
 - d. Thermowells shall be constructed of the following materials:
 - 1) Hot Water; brass.
 - 2) Chilled Water; brass.
 3. Outside Air Sensors
 - a. Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.
 - b. Sensors exposed to wind velocity pressures shall be shielded by a perforated plate surrounding the sensor element.
 - c. Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.
 - d. Solar load sensors shall be provided in locations shown. The use of a thermistor combined with a solar compensator is acceptable. Provide calibration charts as part of the O&M Manual.
 4. Duct Type Sensors
 - a. Duct mount sensors shall mount in a hand box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement. A neoprene grommet (sealtite fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
 - b. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Duct sensors probe shall be constructed of 304 stainless steel.
 - c. For outdoor air duct applications, use a weatherproof mounting box with weatherproof cover and gasket.
 5. Averaging Duct Type Sensors
 - a. Where called out on the drawings and points lists, provide averaging type duct sensors. Thermistor sensors are acceptable. The sensor shall be multi-point sensitive through the length of the temperature conducting tubing. The thermistors shall be configured in a series / parallel method which creates an end result of total average resistance equal to the same span as a standard thermistor.
 - b. Provide capillary supports at the sides of the duct to support the sensing element.
 6. Acceptable Manufacturers
 - a. Honeywell
 - b. Johnson Controls
 - c. ACI
 - d. Bapi
- C. Relative Humidity Sensors/Transmitters

1. The sensor shall be a solid state, resistance type relative humidity sensor of the Bulk Polymer Design. The sensor element shall be washable and shall resist surface contaminations.
2. Humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2 wire isolated loop powered, 4-20ma, 0-10.0 VDC linear proportional output.
3. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion.
 - a. Room Type Sensor $\pm 2\%$ RH
 - b. Duct Type Sensor $\pm 2\%$ RH
4. Outside air relative humidity sensors shall be installed in a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.
5. Provide a single point humidity calibrator, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.
6. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.
7. Acceptable Manufacturers:
 - a. Vaisala
 - b. ACI
 - c. Veris
 - d. Honeywell
 - e. Johnson Controls

D. Differential Pressure Transmitters and Accessories

1. General Air and Water Pressure Transmitter Requirements:
 - a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
 - b. Pressure transmitters shall provide the option to transmit a 0 to 5V dc, 0 to 10V dc, or 4 to 20 mA output signal.
 - c. Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device and shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (3 valve manifolds).
 - d. Provide a minimum of a NEMA 1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
 - e. Low air pressure, differential pressure transmitters used for room pressurization control (i.e. laboratories, OR's clean rooms, etc.) shall be equipped with a LED display indicating the transmitter output signal.
 - f. Duct sensing pressure applications where the velocity exceeds 1500 fpm shall utilize a static pressure traverse probes.
2. Low Air Pressure Applications
 - a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
 - 1) Span: Not greater than two times the design space DP.
 - 2) Accuracy: Plus or minus 0.5% of F.S.
 - 3) Dead Band: Less than 0.3% of output.
 - 4) Repeatability: Within 0.2% of output.
 - 5) Linearity: Plus or minus 0.2% of span.

- 6) Response: Less than one second for full span input.
 - 7) Temperature Stability: Less than 0.05% output shift per degree change.
 - b. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
 - c. Acceptable Manufacturers
 - 1) Auto Tran
 - 2) Veris
 - 3) Setra
 3. Medium to High Air Pressure Applications
 - a. The pressure transmitter shall be similar to the Low Air Pressure Transmitter except the performance specifications are not as severe. Provide differential pressure transmitters which meet the following performance requirements.
 - 1) Zero & span: (% F.S./Deg. C): .05% including linearity, hysteresis and repeatability
 - 2) Accuracy: 1% F.S. (best straight line)
 - 3) Static Pressure Effect: 0.5% F.S.
 - 4) Thermal Effects: $\pm 0.05\%$ F.S. /Deg. C.
 - b. Acceptable manufacturers:
 - 1) Auto Tran
 - 2) Veris
 - 3) Setra
- E. Low Differential, Water Pressure Applications
 1. The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20mA output in response to variation of flow meter differential pressure or water pressure sensing points.
 2. The differential pressure transmitter shall have non-interactive zero and span adjustments adjustable from the outside cover and meet the following performance specifications.
 - a. 0 – 10 input differential pressure range
 - b. 4 - 20 mA output
 - c. Maintain accuracy up to 20 to 1 ratio turndown
 - d. Reference Accuracy: $\pm 0.2\%$ of full span
 3. Provide a two year warranty for each transmitter. Replace all transmitters found to be defective at no cost to the Owner during the warranty period. Acceptable Manufacturers:
 - a. Tobar
 - b. Veris
 - c. Foxboro
 - d. Omega
 - e. Bailey
 - f. Modus
- F. Medium to High Differential Water Pressure Applications
 1. The differential pressure transmitter shall meet the low pressure transmitter specifications except the following:
 - a. Reference Accuracy: $\pm 1\%$ of full span (includes non-linearity, hysteresis, and repeatability)
 - b. Warranty: 1 year.
 2. Acceptable Manufacturers:
 - a. Auto Tran

- b. Veris
 - c. ACI
 - d. Setra
3. Bypass Valve Assembly: Mount stand-alone pressure transmitters in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with hi and low connections piped and valved. Air bleed units, bypass valves and compression fittings shall be provided

G. Electronic Valve And Damper Actuators

- 1. General Requirements
 - a. Electronic actuators shall be electric, direct-coupled type capable of being mounted over the shaft of the damper. They shall be UL listed and the manufacturer shall provide a 2 year unconditional warranty from the date of commissioning. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.
 - b. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burn-out. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
 - c. Warranty must be two years by manufacturer on actuator as a whole and all components.
 - d. Acceptable manufacturers:
 - 1) Honeywell
 - 2) Johnson Controls
 - 3) Belimo
- 2. Control Damper Actuators
 - a. OA (outside air), RA (return air), and EA (exhaust air) actuators shall be spring return type for safety functions. Individual battery backup, capacitor return is not acceptable.
 - b. The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within $\pm 1/21$ of control signal. A 2 - 10 v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within $\pm 2.5\%$.
 - c. Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.
- 3. Miscellaneous Damper Actuators
 - a. OA combustion and ventilation air intake and EA damper actuators shall be 2 position spring return closed if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing. Otherwise drive open, drive closed type 2 position may be used.
 - b. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all air handling equipment handling 100% outside air.
- 4. Air Terminals

- a. Air terminal actuators shall use fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controllers' requirements.
 5. Combination Smoke and Fire Damper Actuators
 - a. Actuators shall be factory mounted and connected to the damper section and shall conform to UL 555S specifications.
- H. Valve Actuators
1. Control Valves Actuators (3 inch and smaller)
 - a. Actuators shall have a gear release button on all non-spring return models to allow manual setting. The actuator shall have either an insulating air gap between it and the linkage or a non-conducting thermoplastic linkage. Care shall be taken to maintain the actuator's operating temperatures and humidity within its specifications. Pipes shall be fully insulated and heat shields shall be installed if necessary. Condensation may not form on actuators and shall be prevented by a combination of insulation, air gap, or other thermal break.
 - b. The control circuit shall be fully modulating using 2 - 10 volt or 4 - 20 mA signals. Accuracy and repeatability shall be within 1/21 of control signal. A 2 - 10 v or 4 - 20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators which are paralleled off a master motor or to provide a feedback signal to the automation system indicating valve position.
 - c. Valve body and actuators shall be shipped fully assembled and tested at the valve factory prior to shipment.
 2. Control Valve Actuators (4 inch and larger).
 - a. The valve actuator shall consist of a permanent split capacitor, reversible type electric motor which drives a compound epicycle gear. The electric actuator shall have visual mechanical position indication, readable from a distance of 8 meters, showing output shaft and valve position. Unit shall be mounting directly to the valves without brackets and adapters, or readily adapted to suit all other types quarter-turn valves.
 - b. The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries shall have UL recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
 - c. The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.
 - d. The actuator shall have a self-locking gear train which is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with 70 N-m or more output torque shall have two adjustable factory calibrated mechanical torque limit switches of the single-pole, double-throw type. The motor shall be fitted with thermal overload protection. Motor rotor shaft shall run in ball bearings at each end of motor.
 - e. The actuator housing shall be hard anodized aluminum for full environmental protection.
 - f. The environmental temperature range of the actuator shall be -22 to 140 deg F.
 - g. For intermittent on/off service, the actuator shall be rated at a 20% duty cycle (i.e., 12 minutes extended duty in every hour, or alternatively; one complete cycle every 2 minutes). For more frequent cycling and modulating service, an actuator shall be rated for continuous duty. The actuator rated for continuous duty shall be capable of operating 100% of the time at an ambient temperature of 104 deg F.

- h. The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15° in each direction of 90° rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as option.
- i. Single Phase Motor: The motor shall have Class B insulation capable of withstanding locked-rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cut-out protector shall be embedded in the motor windings to limit heat rise to 175 deg F in a 104 deg F ambient. All motors shall be capable of being replaced by simply disconnecting the wires and then removing mounting bolts. Disassembly of gears shall not be required to remove the motor.
- j. Materials of Construction: The electric actuator shall have a pressure die-cast, hard anodized aluminum base and cover. The compound gear shall be made of die-cast, hard anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.
- k. Accessories:
 - 1) Potentiometer for providing continuous feedback of actuator position at the controller (for valves specified position feedback).
- l. Acceptable manufacturers:
 - 1) Honeywell
 - 2) Johnson Controls
 - 3) Belimo

I. Control Valves

- 1. Control valves shall be 2-way or 3-way pattern as shown constructed for tight shutoff and shall operate satisfactorily against system pressures and differentials. Two-position valves shall be 'line' size. Proportional control valves shall be sized for a maximum pressure drop of 5 ft of head pressure drop at rated flow (except as may be noted on the drawings). Valves with sizes up to and including NPS 2 shall be "screwed" configuration and NPS 2-1/2 inch and larger valves shall be "flanged" configuration. Electrically controlled valves shall include spring return type actuators sized for tight shut-off against system pressures and furnished with integral switches for indication of valve position (open-closed). Three-way butterfly valves, when utilized, shall include a separate actuator for each butterfly segment.
- 2. Acceptable manufacturers:
 - a. Honeywell
 - b. Belimo

J. Switches

- 1. Differential Pressure Switches
 - a. All pressure sensing elements shall be corrosion resistant. Pressure sensing elements shall be bourdon tubes, bellows, or diaphragm type. Units shall have tamper-proof adjustable range and differential pressure settings.
 - b. Pressure sensor switch contacts shall be snap action micro-switch type. Sensor assembly shall operate automatically and reset automatically when conditions return to normal. Complete sensor assembly shall be protected against vibration at all critical movement pivots, slides and so forth.

- c. Differential pressure switches shall be vented to withstand a 50% increase in working pressure without loss of calibration.
 - d. Acceptable Manufacturers: Mercoid, Dryer, McDonnell Miller.
- 2. Electric Low Limit Thermostat (Freeze Stat)
 - a. Duct type, fixed 4 deg F differential, range 32 to 60 deg F. Sensing element shall be a 20 feet long capillary tube responding to the lowest temperature sensed along any 12 inches of bulb length. Switch shall be SPDT 120/240 volts AC, rated for 10 amps at 120 volts full load. Unit shall be manually reset. Provide one low limit thermostat for each 20 sq. ft. or fraction thereof of coil surface area.
 - b. Provide DPST switches, 1 NO, 1 NC contact.
 - c. Provide manual type low limit thermostat set at 36 deg F on each air handling unit.
 - d. Provide thermostat override on air handling units for smoke control in area being served.
- 3. Water Flow Switches
 - a. UL listed, suitable for all service application conditions. Body minimum working pressure rating shall equal or exceed service pressure. Switch electrical rating shall be 230 volts AC 3.7 ampere, 115 volts AC 7.4 ampere, and 125 VAC 115-230 VAC AC Pilot duty. Unit shall have two SPDT switches. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Flow switch shall not cause pressure drop exceeding 2 psi at maximum system flow rate.
 - b. Acceptable Manufacturer: McDonnell-Miller.
- 4. Strap-On Aquastat
 - a. UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Switch set-point shall be as indicated. Electrical rating shall be 5 amperes, 120 VAC.
- 5. Current Sensitive Switches: Solid state, split core current switch that operates when the current level (sensed by the internal current transformer) exceeds the adjustable trip point. Current switch to include an integral LED for indication of trip condition and a current level below trip set point.

K. Flow, Pressure And Electrical Measuring Apparatus

- 1. Shielded Static Pressure Sensor
 - a. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 3/8" compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
 - b. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow of 1000 feet/min. from a radial source.
 - c. The shielded static sensing devices shall be used for both reference and space pressure sensing.
 - d. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.
- 2. Static Pressure Traverse Probe
 - a. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.

- b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
- c. The duct static traverse probe shall be of 304 stainless steel construction and (except for 3/4" dia. probes with lengths of 24 inches or less) be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure without need for correction factors, with an instrument accuracy of $\pm 1/2\%$.
- d. Acceptable Manufacturers:
 - 1) Auto Tran
 - 2) Veris
 - 3) Setra

L. Relays And Contactors

- 1. Relays other than those associated with digital output cards shall be general purpose, enclosed type and protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required.
- 2. Solid State Relays (SSR): Input/output isolation shall be greater than 10^9 ohms with a breakdown voltage of 1500V root mean square or greater at 60 Hz. The contact life shall be 10×10^6 operations or greater. The ambient temperature range of SSRs shall be -18 to 140 deg F. Input impedance shall not be less than 500 ohms. Relays shall be rated for the application. Operating and release time shall be for 100 milliseconds or less. Transient suppression shall be provided as an integral part of the relay.
- 3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semipermanent magnets. Contractor shall be double-break-silver-to-silver type protected by arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

M. Temperature Control Panels

- 1. Furnish temperature control panels of code gauge steel with locking doors for mounting all devices as shown. Panels shall conform to NEMA 1 standards, unless otherwise indicated.
- 2. Control panels shall meet all requirements of UL508A and shall be so certified.
- 3. All external wiring shall be connected to terminal strips mounted within the panel.
- 4. Provide engraved phenolic nameplates identifying all devices mounted on the face of control panels and the identification number of the panel.
- 5. A complete set of 'as-built' control drawings (relating to the controls within that panel) shall be furnished within each control panel.
- 6. Uninterruptable Power Supplies
 - a. Lithium Battery
 - b. Integral mounting brackets for mounting within cabinet
 - c. Minimum 350 VA/200W capacity
 - d. 6 Minute protection with 200W Load
 - e. 5 year electronics and battery warranty
 - f. 312 Joule surge suppression
 - g. 2-6ms transfer time
 - h. Minimum 3 receptacles
 - i. UL-1778, cTUVus, FCC, and RoHS Approvals

- j. USB communications interface
- k. Based on Xtreme Power Conversion J60

N. Uninterrupted Power Supply

1. One (1) GXT5, Model GXT5-500LVRT2UXL, 500VA / 500Watts Capacity, 120VAC input and output with 15-minute internal battery plant.
2. System Features:
 - a. True on-line design with PWM sine wave output
 - b. 1.0 Output Power Factor Rating
 - c. Input PF correction with wide input voltage and frequency range for longer battery life
 - d. Efficient three-stage charging technique and comprehensive discharging protection
 - e. +/- 3% output voltage regulation
 - f. Automatic restart after extended outages
 - g. Input and output noise suppression
 - h. Emergency fail safe bypass for mission-critical availability
 - i. Configurable to operate at voltages of 110/115/120/127 VAC
 - j. Automatic and manual battery test feature
 - k. Microprocessor-based control and monitoring

O. Any automatic control dampers not specified to be integral with other equipment. Frames shall not be less than 0.094 inch galvanized steel. Blades shall not be over 8 inches wide nor less than 0.063 inch galvanized steel roll formed. Bearings shall be oilite, ball-bearing or nylon with steel shafts. Side seals shall be stainless steel of the tight-seal spring type. Dampers and seals shall be suitable for temperature ranges of -40 to 200 deg F.

1. Individual damper sections shall have a maximum of 16 sq. ft. of damper surface and each individual damper section to have its own damper operator.
2. All proportional control dampers shall be opposed blade type and all two-position dampers shall be parallel blade types.
3. Dampers shall be sized to meet ductwork or opening size.
4. Dampers shall be ultra-low leakage dampers and the blade edges shall be fitted with replaceable, snap-on, inflatable seals to limit damper leakage to 6 CFM per square foot for dampers in excess of sixteen inches square at 1-inch wg.

P. Thermally Isolated Dampers: Tamco 9000 or equivalent extruded aluminum thermally isolated control dampers with insulated air-foil shaped blades.

Q. Digital Wall Module: Each wall module shall provide temperature and humidity indication to the digital controller.

1. Provide software-limited set point adjustment and occupied/unoccupied override capability where indicated.
2. Module mounted adjustments shall use buttons, no slides or wheels.
3. Where indicated, provide plate type security temperature sensors.

R. Power Monitoring Interface: The Power Measurement Interface (PMI) device shall include the appropriate current and potential (voltage) transformers. The PMI shall be certified under UL-3111. The PMI shall perform continuous true RMS measurement based on 32 samples-per-cycle sampling on all voltage and current signals. The PMI shall provide outputs to the BMS based on the measurement and calculation of the following parameters: (a) current for each phase and average of all three phases, (b) kW for each

phase and total of all three phases, (c) power factor for each phase and all three phases, (d) percent voltage unbalance and (e) percent current unbalance. These output valves shall be hard-wired inputs to the BMS or shall be communicated to the BMS over the open-protocol LAN.

- S. Water Flow Meters: Water flow meters shall be axial turbine style flow meters which translate liquid motion into electronic output signals proportional to the flow sensed. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag. Flow meters shall be 'insertion' type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown. Accuracy shall be $\pm 2\%$ of actual reading from 0.4 to 20 feet per second flow velocities.
- T. Duct smoke detectors shall be furnished and connected to the building fire alarm under Division 28. Contacts shall be provided for the BMS contractor to connect for fan shutdown as specified in the Sequence of Operations.
- U. Carbon Dioxide sensors shall be 0-10 Vdc analog output type, with corrosion free gold-plated Non-dispersive Infrared sensing, designed for duct mounting. Sensor shall incorporate internal diagnostics for power, sensor, analog and output checking, and Automatic Background Calibration algorithm for reduced maintenance. Sensor range shall be 0-3000 PPM with $\pm 5\%$ and ± 50 PPM accuracy.
- V. Fan Inlet Airflow Probes:
 - 1. Provide thermal airflow probes on AHU fan inlets capable of continuously measuring the fan air volume.
 - a. There shall be two airflow probes, one sensor per probe for each fan inlet using thermal dispersion technology.
 - b. Each airflow sensor shall have a calibrated range of 0-10,000 FPM, with a NIST traceable accuracy of $\pm 2\%$ of reading for velocity measurement and 0.1°F for temperature measurement. Individual sensors shall be fully field serviceable without need for field calibration, not requiring that the probe be returned to the Factory for repair and/or calibration
 - c. The transmitter will have a high visibility backlit LCD for display of either the averaged or individual sensor airflow and temperature measurements, in user selectable units of measure. The transmitter shall be factory configured to output duct air to building BMS.
 - 2. The airflow probes shall be Air Monitor ELECTRA/flo/FI or Ebtron GTx108.
- W. Duct Mounted Airflow Measuring Station:
 - 1. Provide where indicated, thermal airflow measuring stations capable of continuously monitoring the duct airflow.
 - 2. Each airflow probe array shall consist of one or more multi-point measuring probes and a single microprocessor based transmitter. The transmitter shall be supplied by the same manufacturer as the measuring station or probe array.
 - 3. Each multi-point probe shall be assembled using heavy wall anodized aluminum tubing, aluminum mounting plates, aerodynamically optimized molded sensing apertures to ensure accurate measurement in angular airflow conditions, and neoprene mounting gasket.
 - 4. The airflow measuring station housings shall have a 14 gauge galvanized steel, 8" deep welded casing with 90° connecting flanges. If minimum straight inlet duct diameters are not met, a 3" deep aluminum honeycomb air straightener positioned in front of the measuring probes shall be furnished. The maximum allowable unrecovered pressure drop caused by the station shall not exceed .08" w.c. at 2000 FPM.

5. Each airflow sensor shall have an operating range of 150-5000 FPM, with a NIST traceable accuracy of $\pm 2\%$ of reading for velocity measurement and 0.1°F for temperature measurement.
6. When installed per the manufacturer's minimum installation requirements, the transmitter with accompanying station probes shall measure with an accuracy of $\pm 2-3\%$ of actual flow.
7. The airflow probes shall be Air Monitor ELECTRA/flo/M, /CM, or Ebtron Gold series GTx116. with class "C" density.

2.17 FLOW AND BTU METERS

- A. Water Flow Meters: ONICON Model F-3500 water flow meters shall be electromagnetic style flow meters which translate liquid motion into electronic output signals proportional to the flow sensed. Flow meters shall be 'insertion' type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown. Accuracy shall be $\pm 1\%$ of actual reading from 2 to 20 feet per second flow velocities.
 1. Include display module for BMS interface and local indication of flow rate and total.

PART 3 - EXECUTION

3.1 GENERAL

- A. The BMS shall be designed, installed, and commissioned in a turnkey operational manner; including all labor not noted in Work by Others paragraph of PART I of this section of these specifications, and not noted in other sections of these specifications.
- B. Where control devices are installed on insulated piping or ductwork, provide standoff brackets or thermowells sized to clear insulation thickness. Provide extended sensing elements, actuator linkages, and other accessories as required.

3.2 SEQUENCE OF OPERATION

- A. Refer to drawings for sequence of operations.

3.3 INSTALLATION

- A. All controls Installer work shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work.
- B. Line and low voltage electrical connections to control equipment shall be provided by the controls Installer in accordance with these specifications.
- C. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.
- D. All wiring and tubing shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All tubing and wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to

devices and terminals. All wiring shall be in accordance with all local and national codes. All line voltage wiring, all wiring exposed, and all wiring in equipment rooms shall be installed in conduit in accordance to the electrical specifications. All electronic wiring shall be #18 AWG minimum THHN and shielded if required, except standard network (Ethernet, LonWorks, etc.) cabling shall be as tested and recommended in lieu of #18 gauge twisted, #22 or #24 gauge is acceptable if used as a part of an engineered structured cabling system. The control manufacturer must submit technical and application documentation demonstrating that this cabling system has been tested and approved for use by the manufacturer of both the control system and the engineered structured cabling system.

1. Low voltage system cables shall be neatly routed and independently supported with cable rings to the nearest cable tray, technology closet, conduit run or equipment connection.
 2. All wiring in ceiling plenums shall be plenum rated.
- E. This contractor shall provide all sensing, control, and interlock wiring and tubing for the following unless shown or specified elsewhere by others:
1. Boiler interlocks.
 2. Condensing units interlocks.
 3. Hydronic piping pressure sensors.
 4. CO2 sensors.
 5. Connection between occupancy sensors provided by Division 26 and control devices.
 6. Smoke detection devices and HVAC equipment shut-down devices.
- F. The controls contractor shall install all software and enter all computer data into the network area controllers, operator work stations , laptop computers, hardware, and related computers including all control programs, initial approved parameters and settings, and graphics.
- G. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install wall-mounting devices in electrical outlet boxes at heights to match lighting controls.
- H. For airflow monitoring devices, perform the following field tests and inspections and prepare test reports:
1. Operational Test: After substantial completion of airflow system, start units to confirm proper operation and readings. Remove and replace malfunctioning units and retest.
 2. Test calibration to confirm proper operation and readings.
- 3.4 ACCEPTANCE
- A. The BMS contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations.
1. Coordinate with other Installers the checkout of each controlled system
- B. The controls Installer shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.

- C. Upon completion of the performance tests described above, repeat these tests, point by point as described in the validation log above in presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.
- D. System Acceptance: Satisfactory completion is when the controls Installer has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.5 TRAINING

- A. All training shall be by the BMS Installer and shall utilize operators' manuals and as-built documentation.
- B. The controls Installer shall provide 40 hours of instruction to the Owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; device programming software, graphical development software, graphical user interface, the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation.
- C. The training shall be in three sessions as follows:
 - 1. Initial Training: One day session (8 hours) after system is started up and at least one week before first acceptance test. Manual shall have been submitted at least two weeks prior to training so that the Owners' personnel can start to familiarize themselves with the system before training begins.
 - 2. Follow-Up Training: Two one day sessions (8 hours each) after initial training, and before Formal Acceptance. These sessions will deal with more advanced topics and answer questions.
 - 3. Warranty Follow Up: Two one day sessions (8 hours each) to be scheduled at the request of the Owner during the one year warranty period. These sessions shall cover topics as requested by the owner such as; how to add additional points, create and gather data for trends, graphic screen generation or modification of control routines.
- D. On-Line Service: Include 40 hours of on-line service assistance to include but not be limited to:
 - 1. Programming changes or modifications, including changes and adjustments to control algorithms
 - 2. Graphic changes or modifications as requested by the Owner or consulting engineer.
 - 3. Operator assistance to include short (1 hour or less) refresh training on system diagnostics and operation, i.e., geothermal optimization, scheduling, trending or operator setup.
 - 4. Consulting engineer assistance to include assistance on control system optimization.

3.6 POINTS LIST

- A. Refer to drawings for points list. Provide all additional points as required to accomplish all BMS sequences indicated in the drawings and specifications.

END OF SECTION 23 0900

SECTION 23 1123 - FACILITY NATURAL GAS PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Mechanical sleeve seals.

1.2 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Piping specialties.
2. Corrugated, stainless-steel tubing with associated components.
3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
4. Pressure regulators. Indicate pressure ratings and capacities.
5. Dielectric fittings.
6. Mechanical sleeve seals.
7. Escutcheons.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For pressure regulators to include in emergency, operation, and maintenance manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of natural-gas service.
 - 2. Do not proceed with interruption of natural-gas service without Construction Manager's written permission.

1.7 COORDINATION

- A. Coordinate the installation of the natural gas service by the local gas utility.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Face: Lapped.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel.
- B. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. OmegaFlex, Inc.
 - b. Parker Hannifin Corporation; Parflex Division.
 - c. Titeflex.
 - d. Tru-Flex Metal Hose Corp.
2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
3. Coating: PE with flame retardant.
 - a. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1) Flame-Spread Index: 25 or less.
 - 2) Smoke-Developed Index: 50 or less.
4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
5. Striker Plates: Steel, designed to protect tubing from penetrations.
6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
7. Operating-Pressure Rating: 5 psig.

C. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

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

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

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

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Manual Gas Shutoff Valve Schedules" below for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig.
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Tamperproof Feature: Locking feature for valves indicated in "Manual Gas Shutoff Valve Schedule" Articles.
 - 4. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 - 5. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- C. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.
 - 1. CWP Rating: 125 psig.
 - 2. Threaded Ends: Comply with ASME B1.20.1.
 - 3. Flanged Ends: Comply with ASME B16.5.
 - 4. Tamperproof Feature: Locking feature for valves indicated in "Manual Gas Shutoff Valve Schedule" Articles.
 - 5. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated bronze.
 - 4. Stem: Bronze; blowout proof.
 - 5. Seats: Reinforced TFE; blowout proof.
 - 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 - 7. Ends: Threaded.

8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

E. Bronze Plug Valves: MSS SP-78.

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

F. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McDonald, A. Y. Mfg. Co.
 - b. Mueller Co.; Gas Products Div.
 - c. Xomox Corporation; a Crane company.
2. Body: Cast iron, complying with ASTM A 126, Class B.
3. Plug: Bronze or nickel-plated cast iron.
4. Seat: Coated with thermoplastic.
5. Stem Seal: Compatible with natural gas.
6. Ends: Threaded or flanged.
7. Operator: Square head or lug type with tamperproof feature where indicated.
8. Pressure Class: 125 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

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

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

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig.

2.6 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.

- c. Hart Industries International, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - f. Wilkins; Zurn Plumbing Products Group.
2. Minimum Operating-Pressure Rating: 150 psig.
 3. Combination fitting of copper alloy and ferrous materials.
 4. Insulating materials suitable for natural gas.
 5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - d. Wilkins; Zurn Plumbing Products Group.
2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico Inc.
 - c. Central Plastics Company.
 - d. Pipeline Seal and Insulator, Inc.
2. Minimum Operating-Pressure Rating: 150 psig.
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.7 VALVE WALL BOX (MASTER GAS VALVE)

- A. Master gas valve wall boxes shall be recessed, constructed of painted steel or aluminum with turned out flange on all four sides. Box shall be large enough to enclose the shut-off valve in both the open and closed position.
- B. The access door shall be hinged and have keyed lock. Provide three sets of keys for each lock.
- C. The Installer shall provide the gas cock with lever handle and install it within the valve box.

- D. A label shall be affixed to the valve in the box and the access door shall also be labeled identifying the valve as a master gas shutoff valve.

2.8 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.9 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
 - 3. Pressure Plates: Plastic.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

2.10 ESCUTCHEONS

- A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
- B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Escutcheons: With set screw.
 - 1. Finish: Polished chrome-plated or rough brass.
- D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
- F. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.11 LABELING AND IDENTIFYING

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

PART 3 - EXECUTION

3.1 GAS SERVICE

- A. Arrange and pay for the installation of the natural gas service piping by the local gas utility. The Contractor shall be responsible for all fees and charges required by the local gas utility for complete installation, inspection, and testing of the system.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with the International Fuel Gas Code requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Install underground, natural-gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- C. Install underground, PE, natural-gas piping according to ASTM D 2774.
- D. Install fittings for changes in direction and branch connections.
- E. 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.
- F. 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.

- G. Install pressure gage downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.4 INDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install escutcheons at penetrations of interior walls, ceilings, and floors.
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - c. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.
 - d. Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - e. Piping in Equipment Rooms: One-piece, cast-brass type.
 - f. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- K. 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 in Division 07 Section "Penetration Firestopping."
- L. Verify final equipment locations for roughing-in.
- M. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

- N. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- O. Extend relief vent connections for line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, and floors unless indicated to be exposed to view.
- Q. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. Underground Piping Beneath Buildings: Install underground piping beneath buildings encased in a code approved conduit designed to withstand superimposed loads and the same pressure as the pipe.
 - 3. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.
- R. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- S. Connect branch piping from top or side of horizontal piping.
- T. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- U. Do not use natural-gas piping as grounding electrode.
- V. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- W. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."
- X. Install automatic gas shutoff valve furnished by food service equipment supplier.
- Y. Make final connection to gas-fired kitchen equipment furnished by food service equipment supplier.

3.5 VALVE INSTALLATION

- A. Install manual gas shutoff valve at each gas-fired piece of equipment.

- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- C. Install motorized gas shutoff valve for classroom shut-off as indicated with switch at teacher's demonstration table.
- D. Install master gas shutoff valve for classroom in wall box outside classroom as indicated.

3.6 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 - 4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 - 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
- E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
- F. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain-End Pipe and Fittings: Use butt fusion.
 - 2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.

5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

3.8 CONNECTIONS

- A. Install piping adjacent to appliances to allow service and maintenance of appliances.
- B. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
 1. Install pressure regulator at connection to gas-fired appliance and equipment as required to meet maximum gas pressure requirements of that particular device.
- C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.
- B. Paint exposed, exterior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
 1. Color to be safety yellow .
- C. Paint interior exposed metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
 1. Color to be safety yellow for exposed piping in mechanical rooms.
 2. Color to match building wall/ceiling color for exposed piping in finished spaces.

3.11 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.

- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.12 OUTDOOR PIPING SCHEDULE

- A. Underground natural-gas piping shall be the following:
 - 1. PE pipe and fittings joined by heat fusion; terminated in an accessible location.
- B. Aboveground natural-gas piping shall be the following:
 - 1. For NPS 2 and smaller, use steel pipe with malleable-iron fittings and threaded joints.
 - 2. For NPS 2-1/2 and larger, use steel pipe with wrought-steel fittings and welded joints.

3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

- A. Aboveground, branch piping NPS 1 and smaller shall be one of the following:
 - 1. Corrugated stainless-steel tubing with mechanical fittings having threaded ends to match adjacent piping. Use at appliance connection only.
 - 2. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping shall be one of the following:
 - 1. For NPS 2 and smaller, use steel pipe with malleable-iron fittings and threaded joints.
 - 2. For NPS 2-1/2 and larger, use steel pipe with wrought-steel fittings and welded joints.
- C. Underground, below building, piping shall be the following:
 - 1. For NPS 2 and smaller, use steel pipe with malleable-iron fittings and threaded joints with containment conduit.
 - 2. For NPS 2-1/2 and larger, use steel pipe with wrought-steel fittings and welded joints with containment conduit.
- D. Underground Containment Conduit: Code approved conduit designed to withstand superimposed loads and the same pressure as the pipe.
- E. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating.

3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- B. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

C. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be[**one of**] the following:

1. Bronze plug valve.
2. Cast-iron, nonlubricated plug valve.
3. Cast-iron, lubricated plug valve.

D. Valves in branch piping for single appliance shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 23 1123

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SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
1. Hot-water heating piping.
 2. Chilled-water piping.
 3. Makeup-water piping.
 4. Condensate-drain piping.
 5. Air-vent piping.
- B. Related Sections include the following:
1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
 2. Division 23 Section "Common Work Results for HVAC" for general piping materials and installation requirements.
 3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe expansion compensating devices for hydronic piping systems.
 4. Division 23 Section "Meters and Gages for HVAC Piping" for thermometers and pressure gages.
 5. Division 23 Section "General Duty Valves for HVAC Piping" for general-duty ball, butterfly, and check valves.
 6. Division 23 Section "Hangers and Supports for HVAC Equipment" for pipe supports, product descriptions, and installation requirements. Hanger and support spacing is specified in this Section.
 7. Division 23 Section "Identification for HVAC Piping and Equipment" for labeling and identifying hydronic piping.
 8. Division 23 Section "Instrumentation and Control for HVAC" for temperature-control valves and sensors.
 9. Division 23 Section "HVAC Water Treatment" for pipe cleaning and water treatment for HVAC systems.
 10. Division 23 Section "Radiant Heating Hydronic Piping" for radiant floor heating systems.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
1. Pressure-seal fittings.
 2. Calibrated Balancing Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves.
 3. Air control devices.
 4. Hydronic specialties.
 5. Dielectric fittings.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:

- 1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

- B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

- C. Comply with the provisions of the following:

- 1. Michigan Mechanical Code

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

- C. Wrought-Copper Fittings: ASME B16.22.

- D. Copper or Bronze Pressure-Seal Fittings:

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Viega.
 - b. NIPCO Press.
 - c. Apollo "Xpress"
 - 2. Housing: Copper.
 - 3. O-Rings and Pipe Stops: EPDM.
 - 4. Tools: Manufacturer's special tools.
 - 5. Minimum 200-psig working-pressure rating at 250 deg F.

- E. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. T-DRILL Industries Inc.

F. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 125, raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 1. Material Group: 1.1.
 2. End Connections: Slip-on or butt welded.
 3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 DUCTILE IRON PIPE AND FITTINGS

- A. Ductile Iron Pipe: AWWA C151/A21.51.
- B. Fittings: AWWA C110/A21.10, ductile iron, standard thickness.
 1. Joints: AWWA C111/A21.11, rubber gasket with 3/4 inch diameter rods.

2.4 PLASTIC PIPE AND FITTINGS

- A. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.
- B. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 pipe.
- C. PVC Solvent Cement: ASTM D 2564.

2.5 PEX PIPE AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. HeatLink USA Inc.
 - 2. Mr. PEX
 - 3. Viega LLC.
 - 4. Uponor.
 - 5. Watts Radiant, Inc.; a division of Watts Water Technologies, Inc.
 - 6. Zurn Plumbing Products Group.
- B. Pipe Material: Crosslinked polyethylene (PEX), manufactured in accordance with ASTM F876 and ASTM F877.
- C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
- D. Fittings: ASTM F1960 metal cold expansion or ASTM F 1807, metal insert and crimp rings.
- E. Pressure/Temperature Rating: Minimum 100 psig and 180 deg F.

2.6 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 thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- F. Solvent Cements for Joining Plastic Piping:
 - 1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
- G. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.7 DIELECTRIC FITTINGS

- A. Refer to Division 23 Section "Common Work Results for HVAC" for dielectric fittings.

2.8 VALVES

- A. Butterfly, Check, and Ball Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."
 - 1. Valves with factory ends meeting requirements of Section "General Duty valves for Plumbing Piping" may be used in mechanical joint copper press systems.
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Furnished by temperature controls provider. Refer to Division 23 Section "Instrumentation and Control for HVAC."
- C. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett.
 - b. Tour & Andersson.
 - 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Plug: Resin.
 - 5. Seat: PTFE.
 - 6. End Connections: Threaded or socket.
 - 7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 8. Handle Style: Lever, with memory stop to retain set position.
 - 9. CWP Rating: Minimum 125 psig.
 - 10. Maximum Operating Temperature: 250 deg F.
- D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett.
 - b. Tour & Andersson.
 - c. Watts Industries, Inc.; Water Products Div.
 - 2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Stem Seals: EPDM O-rings.
 - 5. Disc: Glass and carbon-filled PTFE.
 - 6. Seat: PTFE.
 - 7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 8. Handle Style: Lever, with memory stop to retain set position.
 - 9. CWP Rating: Minimum 125 psig.
 - 10. Maximum Operating Temperature: 250 deg F.
- E. Diaphragm-Operated, Pressure-Reducing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bell & Gossett.
 - 2. Body: Bronze or brass.
 - 3. Disc: Glass and carbon-filled PTFE.

4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bell & Gossett.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Drain Valves:

1. Ball-Valve-Type, Hose-End Drain Valves:
 - a. Standard: MSS SP-110 for standard-port, two-piece ball valves.
 - b. Pressure Rating: 400-psig minimum CWP.
 - c. Size: NPS 3/4.
 - d. Body: Copper alloy.
 - e. Ball: Chrome-plated brass.
 - f. Seats and Seals: Replaceable.
 - g. Handle: Vinyl-covered steel.
 - h. Inlet: Threaded or solder joint.
 - i. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.
2. Gate-Valve-Type, Hose-End Drain Valves:
 - a. Standard: MSS SP-80 for gate valves.
 - b. Pressure Rating: Class 125.
 - c. Size: NPS 3/4.
 - d. Body: ASTM B 62 bronze.
 - e. Inlet: NPS 3/4 threaded or solder joint.
 - f. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.9 AIR CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett.
2. Body: Bronze.
3. Internal Parts: Nonferrous.
4. Operator: Screwdriver or thumbscrew.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/8.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 225 deg F.

B. Automatic Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett.
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bell & Gossett.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett.
 - c. Taco.
3. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested with taps fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
4. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
5. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.

6. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.

D. Bladder-Type Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bell & Gossett.
2. Tank: Welded steel, rated for 125-psig(860-kPa) working pressure and 375 deg F(191 deg C) maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. Air Eliminators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Spirotherm Inc.
 - b. Amtrol, Inc.
 - c. Armstrong Pumps, Inc.
 - d. Bell & Gossett.
 - e. Taco.
 - f. Thrush Co. Inc.
2. Description: Coalescing type air and dirt eliminator, steel fabricated, rated for 150 psig working pressure with internal coalescing bundle consisting of a copper core tube with continuous wound copper medium permanently affixed to the core. Eliminator shall have a separate venting chamber to prevent system contaminants from harming the float and venting valve operation. At the top of the venting chamber shall be an integral full port float actuated brass venting mechanism. Units shall include a valved side tap to flush floating dirt or liquids and for quick bleeding of large amounts of air during system fill or refill. Eliminator shall include a removable bottom head with connection for use as a blow down connection for periodic cleaning.

F. Tangential-Type Air Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Bell & Gossett.
2. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.
7. Strainer: Removable strainer.

2.10 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 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.

B. 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.

C. Terminal Unit Stainless-Steel Flexible Connectors (RCP, VAV, etc.):

1. Tubing: CPE/EPDM inner tube with stainless steel braided cover, fire rated.
2. End Connections: Brass or plated carbon steel fittings with swivel on one end.
3. Working Pressure Rating: 150 psig minimum.
4. Maximum Operating Temperature: 230 deg F.

D. Pipe Cover System:

1. Description: Factory-fabricated vertical and horizontal steel cover support system with concealed surface mounted attachment for concealment of piping and its supports and insulation.
 - a. Cover system shall incorporate a concealed snap-lock connection which, once assembled, renders the cover essentially irremovable with the use of ordinary tools.
2. Cover: Smooth in appearance and made of 18-gauge powder coated steel.
 - a. Color: White.
3. Manufacturer: JG Innovations, Arisco Manufacturing.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2 and smaller, shall be any of the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
2. Schedule 40 steel pipe; Class 125 cast-iron or Class 150 malleable-iron threaded fittings.

B. Hot-water heating piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:

1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

- C. Hot-water heating piping installed below slabs, NPS 2(DN 50) and smaller, shall be the following:
 - 1. Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered or brazed joints. Use the fewest possible joints.
 - 2. Pre-Insulated PEX Tube; fittings for PEX tube; and crimped or cold expansion joints. Joints are not allowed below the slab.
- D. Chilled-water piping, aboveground, NPS 2 and smaller, shall be any of the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
 - 2. Schedule 40 steel pipe; Class 125 cast-iron or Class 150 malleable-iron threaded fittings.
- E. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be the following:
 - 1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
- F. Makeup-water piping installed aboveground, NPS 2 and smaller, shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
- G. Condensate-Drain Piping: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
- H. Air-Vent Piping:
 - 1. Inlet: Same as service where installed.
 - 2. Outlet: Type L, annealed-temper copper tubing with soldered or flared joints.
- I. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 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 valve and calibrated-orifice balancing valve at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating 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; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on 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 drain 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 or where allowed, mechanically formed 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. For expansion compensation at risers and terminals, install connection between piping mains and risers with at least 5 pipe fittings including tee in main. Install connections between piping risers and terminal units with at least 4 pipe fittings including tee in riser.
- Q. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."
- R. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- S. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

- T. Install strainers on inlet side of each in-line pump and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- U. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 HANGERS AND SUPPORTS

- A. Install structural steel members between building structure members as required for upper attachment of hangers and supports. Use members of size and strength required for span and load. The use of joist or truss bridging for hanging and supporting is prohibited.
- B. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
- C. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- D. Install hangers for steel piping with maximum spacing and minimum rod in accordance Michigan Mechanical Code or MSS SP-69.
- E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
- F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.
- G. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2 and Smaller: 48 inches with 3/8-inch rod.
- H. Install supports for vertical PVC piping every 48 inches.

3.5 PIPE JOINT CONSTRUCTION

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

- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- 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 D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - a. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - b. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- I. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.
- J. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only.
- C. Install piping to expansion tank with a 2 percent upward slope toward tank.
- D. Install tangential air separator in pump suction. Install ball valve in blowdown connection. Install blowdown piping; extend full size to nearest floor drain.

- 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 diaphragm type expansion tanks below piping. Ensure tank is properly charged with air to match system fill pressure.
- G. Install bladder type expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to match system fill pressure.
- H. Install flexible connectors at inlet and discharge connections to base mounted pumps and other vibration-producing equipment.
- I. Install flexible hose connectors at inlet and discharge connections to ceiling mounted coil connections.
- J. Install pipe cover system where indicated in accordance with manufacturer's requirements. Paint cover to match surrounding area. Coordinate with Architect.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for test plugs and pressure gages at pumps and elsewhere as indicated according to Division 23 Section "Meters and Gages for HVAC Piping."
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections and elsewhere as indicated according to Division 23 Section "Meters and Gages for HVAC Piping."

3.8 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:
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 bleed air completely.
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment to specified values.
 7. Verify lubrication of motors and bearings.

END OF SECTION 23 2113

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SECTION 23 2114 - UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes underground piping outside the building for distribution of heating hot water, chilled water, cooling tower makeup water, and condenser water.

1.2 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
 - 1. Hot-Water Piping: 100 psig.
 - 2. Chilled-Water Piping: 100 psig.
 - 3. Cooling Tower Makeup-Water Piping: 100 psig.
 - 4. Condenser-Water Piping: 100 psig.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Underground piping system.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - 1. Calculate requirements for expansion compensation for underground piping.
 - 2. Show expansion compensators, offsets, and loops with appropriate materials to allow piping movement in the required locations. Show anchors and guides that restrain piping movement with calculated loads, and show concrete thrust block dimensions.
 - 3. Show pipe sizes, locations, and elevations. Show piping in trench, conduit, and cased pipe with details showing clearances between piping, and show insulation thickness.
- C. Qualification Data: For qualified Installer.
- D. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet and at vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing hydronic piping.
- E. Source quality-control test reports.
- F. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Certify that each installer has been trained by the manufacturer's representative for piping installation.

- B. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

PART 2 - PRODUCTS

2.1 UNDERGROUND PREINSULATED PIPING SYSTEM (HEATING WATER DISTRIBUTION)

- A. Basis-of-Design Product: Subject to compliance with requirements, provide **Uponor** or a comparable product by the following:
1. Insul-Tek Piping Systems, Inc.
 2. PERMA-PIPE, Inc.
 3. Rovanco Piping Systems, Inc.
 4. Thermacor Process, L.P.
 5. Tricon Piping Systems, Inc.
- B. Description: Factory-fabricated carrier piping with insulation and exterior jacket.
- C. Carrier Pipe:
1. Crosslinked polyethylene (PEX) manufactured by PEX-a or Engle method, manufactured in accordance with ASTM F876 and ASTM F877.
 2. Schedule 80 PVC plastic pipe complying with ASTM D 1785 with plain ends for solvent cement joints.
 3. Steel Pipe: ASTM A 53/A 53M, black with plain ends; Schedule 40.
 - a. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- D. Carrier Pipe Insulation:
1. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
 - a. Thermal Conductivity (k-Value): 0.13 at 75 deg F.
 - b. Dry Density: 2 lb/cu. ft. maximum.
 2. Insulation: Rigid cellular polyurethane.
 - a. Thermal Conductivity (k-Value): 0.16 at 73 deg F.
 - b. Dry Density: 2 lb/cu. ft. minimum.
- E. Jacket:
1. HDPE waterproof jacketing material.
 2. Manufacturers standard waterproof jacketing material.
- F. Fittings: Factory-fabricated and -insulated elbows equivalent to the pipe.
- G. Accessories:
1. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.

2. Elbows, tees, reducers, anchors, end seals, anchors and anchor plates.

- H. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved on Coordination Drawings.
- B. Install in strict accordance with manufacturers requirements, including excavating, trenching, and backfilling.
- C. Remove any standing water in the bottom of trench.
- D. Bed the pipe on a minimum 6-inch layer of granular fill material with a minimum 6-inch clearance between the pipes.
- E. Do not backfill piping trench until field quality-control testing has been completed and results approved.
- F. Install piping at uniform grade of 0.2 percent upward in direction of flow or as indicated.
- G. Install components with pressure rating equal to or greater than system operating pressure.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Refer to Division 23 Section "Common Work Results for HVAC" for sleeves and mechanical sleeve seals through exterior building walls.
- K. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 "Cast-in-Place Concrete."
- L. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Division 23 Section "Hydronic Piping."

3.3 IDENTIFICATION

- A. Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic distribution piping. Locate 6 to 8 inches below finished grade, directly over piping. Refer to Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Prepare hydronic piping for testing according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Isolate equipment. Do not subject equipment to test pressure.
 - 3. Install relief valve set at pressure no more than one-third higher than test pressure.
 - 4. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
 - 5. Use vents installed at high points to release trapped air while filling system.
- C. Test piping as follows:
 - 1. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
 - 2. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
- D. Prepare a written report of testing.

END OF SECTION 23 2114

SECTION 23 2123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. In-line centrifugal booster pumps.
2. In-line pumps with ECM.
3. Separately coupled, horizontal, in-line centrifugal pumps.
4. Separately coupled, base-mounted, end-suction centrifugal pumps.
5. Pump specialty fittings.

B. Related Sections include the following:

1. Division 23 Section "Common Work Results for HVAC" for general installation requirements and concrete equipment bases.
2. Division 23 Section "Common Motor Requirements for HVAC Equipment" for general motor requirements and shaft grounding rings.
3. Division 23 Section "Meters and Gages for HVAC Piping" for pressure gauges requirements at pumps.
4. Division 23 Section "Instrumentation and Controls for HVAC" for field installed variable frequency drives for pump motors.
5. [Division 26 Section "Variable Frequency Motor Controllers" for variable frequency drives for pump motors].

1.2 DEFINITIONS

A. Buna-N: Nitrile rubber.

1.3 ACTION SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

1. No pump shall be submitted whose impeller diameter exceeds 90% of the maximum published impeller diameter for the pump, nor an impeller which is less than 15% larger than the smallest published impeller diameter for the pump.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

1. Wiring Diagrams: Power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Alignment Certificate: Include signed certificate verifying based mounted pump alignment procedures have been completed.
- B. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.6 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 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.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Bell & Gossett.

2.2 WET ROTOR INLINE PUMPS

- A. Basis of Design: Bell & Gossett Model ecocirc XL.

- B. Description: Factory-assembled and -tested, wet rotor in-line pumps with ECM motor and integrated variable frequency drive.
1. Pump and Motor Assembly: Motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.
 2. Casing: Cast iron, with companion-flange connections.
 3. Impeller: Plastic or stainless steel.
 4. Shaft: Stainless steel.
 5. Rotor: Permanent magnet.
 6. Bearing: Carbon sleeve.
 7. Gasket/O-Ring: EPDM.
 8. All Other Wetted Parts: Stainless steel.
 9. Motor Type: Electronically commutated motor /permanent magnet and includes:
 - a. Class F motor insulation.
 - b. Integrated motor protection against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
 10. Integrated Variable Frequency Drive: Tested as one unit by the manufacturer and includes:
 - a. MODBUS or BACnet connections built into the VFD as standard.
 - b. Analog inputs, such as 0-10V and 4-20mA inputs built into the VFD.
 11. Maximum Working Pressure: 175 psi.
 12. Maximum Working Temperature: 230°F.

2.3 SEPARATELY COUPLED, HORIZONTAL, IN-LINE CENTRIFUGAL PUMPS

- A. Basis of Design: Bell & Gossett Series 60.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.
- C. Pump Construction:
1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and companion-flange connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.
 5. Pump Bearings: Permanently lubricated ball bearings.
- D. Shaft Coupling: Flexible coupling capable of absorbing vibration.
- E. Motor: Single speed, with permanently lubricated ball bearings and resiliently mounted through 1 HP or rigidly mounted over 1.5 HP to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.4 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

- A. Basis of Design: Bell & Gossett Series e1510.
- B. Description: Factory-assembled and -tested, centrifugal, single stage, separately coupled, end-suction pump; designed for base mounting, with pump and motor shafts horizontal. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.
- C. Pump Construction:
 - 1. Casing: Cast iron, with threaded gage tapings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded or flanged connections. Provide integral mount on volute to support the casing, and attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
 - 2. Impeller: ASTM B 584, cast bronze or cast stainless steel; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. Trim impeller to match specified performance.
 - 3. Pump Shaft: Steel, with stainless steel shaft sleeve.
 - 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket.
- D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.
- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- G. Motor: Single speed, with permanently lubricated ball bearings for 5 HP and smaller motors or with grease-lubricated ball bearings for larger than 5 HP motors; secured to mounting frame, with adjustable alignment. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Refer to Division 23 Section "Common Motor Requirements for HVAC Equipment" for special requirements for motors operated with variable frequency drives.

2.5 AUTOMATIC CONDENSATE PUMP UNITS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Little Giant Pump Co.
 - 2. Beckett Corporation.
 - 3. Hartell Pumps Div.; Milton Roy Co.
 - 4. Sauermann.
- B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and the following electrical power connection:

1. For exposed applications, include a 72-inch- minimum, electrical power cord with plug.
2. For concealed above ceiling applications, include a hard wired electrical power connection.

2.6 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser: Angle pattern, 175-psig pressure rating, ductile or cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support. Manufacturer shall be the same as the pump.
 1. When grooved piping systems allowed, suction diffuser may be as described above except with ductile iron body and cap with grooved piping side connection.
- B. Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, ductile or cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement. Manufacturer shall be the same as the pump.
 1. When grooved piping systems allowed, triple duty valve may be as described above except with ductile iron body with grooved piping connections and 300-psig pressure rating.
 2. When grooved piping systems allowed, in lieu of triple duty valves, tri-service valves from mechanical grooved coupling system provider will be allowed.

PART 3 - EXECUTION

3.1 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of 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. For base-mounted pumps located on slab-on-grade type floors, set pumps on concrete equipment bases. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
 1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- E. For base-mounted pumps located on elevated floors, set pumps on a concrete inertia base on top of a concrete equipment bases. Inertia base shall be fabricated from welded structural steel with the height of the base being 1/12th of the longest dimension. Inertia base shall be mounted on spring isolators, employing height saving clips. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.

1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- F. Trim pump impellers as required to have pump discharge balancing valves no more than 50% closed.

3.2 ALIGNMENT

- A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
1. Alignment procedure to be witnessed by Engineer or Owner representative with witness signing the alignment certificate.
- B. Comply with pump and coupling manufacturers' written instructions.
- C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install triple-duty valve on discharge side of base mounted pumps.
- F. Install suction diffuser and shutoff valve on suction side of base mounted pumps.
1. When grooved piping systems allowed, in lieu of flexible connectors, three flexible connectors from mechanical grooved coupling system provider will be allowed.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
1. When grooved piping systems allowed, in lieu of flexible connectors, three flexible connectors from mechanical grooved coupling system provider will be allowed.

- H. Install pressure gage across pump suction and discharge. Install single gage with metal tubing and multiple input selector valves.
- I. Install check valve and gate or ball valve on each condensate pump unit discharge.
- J. Install electrical connections for power, controls, and devices.
- K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 SHAFT GROUNDING RING INSTALLATION

- A. Factory install at each three phase motor utilizing a variable frequency controller, a shaft grounding ring. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

3.5 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 2123

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SECTION 23 2300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.
- B. Related Sections include the following:
 - 1. Division 23 Sections for smaller equipment furnished with refrigerant line sets.

1.2 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-134a:
 - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
 - 2. Suction Lines for Heat-Pump Applications: 225 psig.
 - 3. Hot-Gas and Liquid Lines: 225 psig.

1.3 ACTION SUBMITTALS

- A. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.
 - 1. Shop Drawing Scale: 1/4 inch equals 1 foot.
 - 2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.8 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- B. Coordinate size and location of equipment supports, and wall penetrations.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type K or L or ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.
- B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.
- C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

- D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Flanged Unions:
 - 1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 and ductile iron for NPS 2 to NPS 3. Apply rust-resistant finish at factory.
 - 2. Gasket: Fiber asbestos free.
 - 3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
 - 4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
 - 5. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
 - 6. Pressure Rating: Factory test at minimum 400 psig.
 - 7. Maximum Operating Temperature: 330 deg F.
- F. Flexible Connectors:
 - 1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
 - 2. End Connections:
 - a. NPS 2 and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 and Larger: With flanged-end connections.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

- A. Diaphragm Packless Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
 - 2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
 - 3. Operator: Rising stem and hand wheel.
 - 4. Seat: Nylon.
 - 5. End Connections: Socket, union, or flanged.
 - 6. Working Pressure Rating: 500 psig.
 - 7. Maximum Operating Temperature: 275 deg F.
- B. Packed-Angle Valves:
 - 1. Body and Bonnet: Forged brass or cast bronze.
 - 2. Packing: Molded stem, back seating, and replaceable under pressure.
 - 3. Operator: Rising stem.
 - 4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
 - 5. Seal Cap: Forged-brass or valox hex cap.
 - 6. End Connections: Socket, union, threaded, or flanged.
 - 7. Working Pressure Rating: 500 psig.
 - 8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: 40 deg F.
6. Superheat: Adjustable or nonadjustable as required by application.
7. End Connections: Socket, flare, or threaded union.

8. Working Pressure Rating: 700 psig or 450 psig as required by application.
- H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 5. Seat: Polytetrafluoroethylene.
 6. Equalizer: Internal or external as required by application.
 7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter.
 8. End Connections: Socket.
 9. Set Pressure: As required by application.
 10. Throttling Range: Maximum 5 psig.
 11. Working Pressure Rating: 500 psig.
 12. Maximum Operating Temperature: 240 deg F.
- I. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
 2. Screen: 100-mesh stainless steel.
 3. End Connections: Socket or flare.
 4. Working Pressure Rating: 500 psig.
 5. Maximum Operating Temperature: 275 deg F.
- J. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
 2. Drain Plug: Brass hex plug.
 3. Screen: 100-mesh monel.
 4. End Connections: Socket or flare.
 5. Working Pressure Rating: 500 psig.
 6. Maximum Operating Temperature: 275 deg F.
- K. Moisture/Liquid Indicators:
1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in ppm.
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.
 6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 240 deg F.
- L. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina or charcoal as required by application.

4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated alumina or charcoal as required by application
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.

- 3. Honeywell, Inc.; Genetron Refrigerants.
 - 4. INEOS Fluor Americas LLC.
- B. ASHRAE 34, R-134a: Tetrafluoroethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-134a

- A. Suction Lines NPS 4 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR or Type L, annealed-temper or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Hot-Gas and Liquid Lines: Copper, Type ACR, Type K, or Type L, annealed-temper or drawn-temper tubing and wrought-copper fittings with soldered joints.
- C. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints, or copper Type ACR, Type K, or Type L, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install valves in suction and discharge lines of compressor.
- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install valves on inlet and outlet side of filter dryers.
- E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- F. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- G. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

- I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- J. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- K. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 2. Install horizontal suction lines with a uniform slope downward to compressor.
 3. Install traps and double risers to entrain oil in vertical runs.
 4. Liquid lines may be installed level.
- P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."
- S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
- V. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

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. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- D. 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.
- E. 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 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. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 3. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 4. NPS 4: Maximum span, 14 feet; minimum rod size, 1/2 inch.
- E. Support multifloor vertical runs at least at each floor.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Comply with ASME B31.5, Chapter VI.
 - 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 - 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 - 1. Open shutoff valves in condenser water circuit.
 - 2. Verify that compressor oil level is correct.
 - 3. Open compressor suction and discharge valves.
 - 4. Open refrigerant valves except bypass valves that are used for other purposes.
 - 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 2300

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SECTION 23 2500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes HVAC water-treatment for the following systems:

1. Heating hot-water.
2. Chilled water.

1.2 PERFORMANCE REQUIREMENTS

- A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:
1. Bypass feeders.
 2. Water meters.
 3. Automatic chemical-feed equipment components.
 4. Cartridge-type filters.
 5. Glycol.
- B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
1. Wiring Diagrams: Power and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- B. Other Informational Submittals:
1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality.
 2. Water Analysis: Illustrate water quality available at Project site.

3. Submit a written report of each system capacity in gallons as recorded from makeup water meter.
4. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers.

1.6 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.7 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion, scale formation, and biological growth for piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
 1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.
 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Service Providers: Subject to compliance with requirements, HVAC water-treatment service provider offering products and services that may be incorporated into the Work include, but are not limited to, the following:
 1. Enerco Corporation.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

- A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch fill opening in the top, and NPS 3/4 bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
 - 1. Capacity: 2 gal..
 - 2. Minimum Working Pressure: 125 psig.

2.3 CHEMICAL TREATMENT TEST EQUIPMENT

- A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing solutions to maintain performance requirements for each required characteristic.
- B. Sample Cooler:
 - 1. Tube: Sample.
 - a. Size: NPS 1/4 tubing.
 - b. Material: ASTM A 666, Type 316 stainless steel.
 - c. Pressure Rating: Minimum 2000 psig.
 - d. Temperature Rating: Minimum 850 deg F.
 - 2. Shell: Cooling water.
 - a. Material: ASTM A 666, Type 304 stainless steel.
 - b. Pressure Rating: Minimum 250 psig.
 - c. Temperature Rating: Minimum 450 deg F.
- C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

2.4 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality requirements.

2.5 FILTRATION EQUIPMENT

- A. Cartridge-Type Filters:
 - 1. Description: Type 304 stainless steel housing with minimum 150 psig pressure rating and 275 degree F temperature rating. For 2 inch inlet and outlet connection units, include support legs, fail-safe removable cover, cover gasket, and drain outlet. For 1 inch inlet and outlet connection units, include support bracket, fail-safe removable cover, cover gasket, and drain outlet. Filter media and support to be 100% stainless steel. Filter media to be cleanable stainless steel cartridges rated at 40 microns. Provide two complete sets of stainless steel filter cartridges.
 - a. Include cotton filters for system startup, one set of 150 micron and one set of 75 micron.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION - GENERAL

- A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
- B. Install water testing equipment on wall near water chemical application equipment.
- C. Provide piping and control connections between components. Coordinate power connections for components with Division 26.

3.3 INSTALLATION OF BYPASS FEEDERS

- A. Install bypass feeders in closed hydronic systems, and equipped with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
 - 2. Install an isolation valves on inlet, outlet, and drain below feeder inlet.
 - 3. Install a swing check on inlet after the isolation valve.

3.4 INSTALLATION OF CARTRIDGE FILTERS

- A. Install cartridge filter in hydronic system where indicated. Install throttling valves on each side of filter.
 - 1. Install 150 micron cotton filter during initial system start-up and use until loaded.
 - 2. Replace with 75 micron cotton filter and use until loaded.
 - 3. Replace with 40 micron stainless steel filters after system cleaning.
- B. Install pressure gage across filter unit to show pressure drop through unit.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results for HVAC."

- D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-Duty Valves for HVAC Piping."
- E. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.
- F. Confirm applicable electrical requirements in Division 26 Sections for connecting electrical equipment.
- G. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- H. Connect wiring according to Division 26 Sections.

3.6 CLEANING AND TREATMENT OF HYDRONIC SYSTEMS

- A. General: Isolate all new piping to be cleaned from existing piping and new equipment. Provide shut-off valves and temporary bypasses as required to maintain circulation through new piping. After cleaning, remove temporary bypasses and open shutoff valves to established circulation through entire system for the water treatment application.
- B. Pre-Cleaning: Thoroughly flush all **[new]**piping with fresh water. Determine loop capacity in gallons using electric contact head type bronze constructed water meter. Fill system from completely dry to full, including air bleed out. Submit written report of system capacity in gallons taken from water meter. Drain system completely. Open drip legs and other non-flow piping to remove debris. Remove and clean all strainers.
- C. Cleaning of Non-Glycol Systems: Refill system with fresh water along with alkaline detergent cleaner. Feed cleaner through bypass feeder at recommended use rates. Circulate 8 to 72 hours. Flush system. Open, clean, and inspect all strainers, drip legs, and non-flow areas. Refill with fresh water, bleed air from system, and allow system to make-up fresh water and bleed air until water leaving system is of same quality as make-up water.
- D. Treatment of Non-Glycol Systems: Immediately introduce corrosion inhibitor through bypass feeder to protect the clean system.
- E. Sectional Cleaning: If entire system is not cleaned and treated at one time, each untreated section shall be isolated from treated sections. Untreated sections to be cleaned and treated as described above **before** connection to a previously treated section. Provide written report for each individual section.
- F. For non-glycol systems, perform tests determining analysis of supply water solution and submit written test results.

END OF SECTION 23 2500

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SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes metal ducts for air-distribution systems.
- B. Related Sections include the following:
 - 1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors, turning vanes, flexible ducts, and flexible connectors.

1.2 SYSTEM DESCRIPTION

- A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Architect/Engineer. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.3 ACTION SUBMITTALS

- A. Product data for the following items:
 - 1. Sealing Materials.
 - 2. Duct Liner.
- B. Duct Leakage Reports: Submit duct leakage test reports. The reports shall be certified proof that the systems have been leak tested, in accordance with this specification section and the referenced standards and are an accurate representation of the system leakage.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. NFPA Compliance:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.6 DELIVERY, STORAGE, AND PROTECTION

- A. Deliver sealant materials to site in original unopened containers or bundles with labels informing about manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHEET METAL MATERIALS

- A. 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: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.
- D. 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.
- E. Bird Screen: 1/2 inch mesh, 16 gage galvanized wire.

2.3 DUCT LINER

- A. Fibrous-Glass Liner: Comply with NFPA 90A or NFPA 90B and with NAIMA AH124.
 - 1. Manufacturers:
 - a. CertainTeed Corp.; Insulation Group.
 - b. Johns Manville International, Inc.
 - c. Knauf Fiber Glass GmbH.
 - d. Owens Corning.
 - 2. Materials: ASTM C 1071; surfaces exposed to airstream shall be coated to prevent erosion of glass fibers.

- a. Thickness: 1 inch.
- b. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
- c. Minimum Duct Liner Performance (Minimum Sound Absorption Coefficient): 125HZ/0.04, 250HZ/0.25, 500HZ/0.57, 1kHz/0.78, 2kHz/0.87, 4kHz/0.89.
- d. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
- e. Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
- f. Mechanical Fasteners: Galvanized steel suitable for mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in duct.
 - 1) Tensile Strength: Indefinitely sustain a 50-lb- tensile, dead-load test perpendicular to duct wall.
 - 2) Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.

2.4 SEALANT MATERIALS

- A. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.
- B. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.
- C. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.5 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. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- B. Install structural steel members between building structure members as required for upper attachment of hangers and supports. Use members of size and strength required for span and load. The use of joist or truss bridging for hanging and supporting is prohibited.
- C. Hanger Materials: Galvanized sheet steel or threaded steel rod.
 - 1. Hangers Installed in Corrosive Atmospheres: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
 - 2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
- D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- E. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

2.6 RECTANGULAR DUCT FABRICATION

- A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.
 1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
 2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- B. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.7 APPLICATION OF LINER IN RECTANGULAR DUCTS

- A. All sizes shown on the drawings for ducts which require duct liner shall be sizes inside the liner.
- B. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
- C. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
- D. Butt transverse joints without gaps and coat joint with adhesive.
- E. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
- F. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and standard liner product dimensions make longitudinal joints necessary.
- G. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
- H. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 1. Fan discharges.
 2. Intervals of lined duct preceding unlined duct.
 3. Upstream edges of transverse joints in ducts where air velocities are greater than 2500 fpm (12.7 m/s) or where indicated.
- I. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.8 FABRICATED PIPE COVERS

- A. General: Provide as indicated carbon steel or stainless steel pipe covers for vertical pipe runs. Pipe covers shall be self supporting, securely attached to building structure with tamper resistant removable fasteners.

2.9 DRYER VENT DUCTWORK

- A. Provide round dryer vent ducts in accordance with SMACNA Standards using snaplock seam ducts with die-formed elbows. Provide cleanouts for ease of duct cleaning.
1. Provide flexible aluminum dryer venting for connection to dryer.
 2. Provide roof curb and gooseneck outlet for roof outlet installations.
 3. Provide plastic wall cap with flapper for wall outlet installations.
- B. Provide flexible aluminum dryer venting and plastic wall cap with flapper.

2.10 KITCHEN HOOD VENT DUCTWORK

- A. Provide ductwork constructed and installed in accordance with SMACNA minimum gauges and requirements. Provide 18 gauge galvanized steel make-up air ductwork and welded 16 gauge galvanized exhaust ductwork as per code requirements and conform to all building requirements and obstructions with all dimensions subject to verification in field. Provide all ductwork with cleanouts every 6'-0" of horizontal run (with pitch as per code) and at changes in direction, access panel, dampers, curbs, flashing, flanges, plenums, supports, insulation, etc. as required by code and to provide a leak proof system.

2.11 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

- A. Spiral Duct Manufacturers:
1. Allied Mechanical Services.
 2. Eastern Sheet Metal.
 3. SET Duct.
 4. LaPine Metal Products.
 5. McGill AirFlow Corporation.
 6. River City Mechanical.
 7. SEMCO Incorporated.
 8. Universal Spiral Air.
 9. Zinger Sheet Metal.
- B. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.
- C. Round Ducts: Fabricate ducts of longitudinal-seam or spiral lock-seam galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

- D. Round, Longitudinal-Seam Ducts: Fabricate 12 inch and smaller ducts and drops to diffusers of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- E. Round, Longitudinal-Seam Ducts: For ductwork down stream of VAV terminal units, fabricate ducts and drops to diffusers of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- F. Round, Spiral Lock-Seam Ducts: Fabricate 13 inch and larger ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.
- G. Round, Spiral Lock-Seam Ducts: For ductwork up stream of VAV terminal units, fabricate ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
- H. Flat-Oval, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible." Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.
- I. Duct Joints:
 - 1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - 2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
 - 3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
- J. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.
- K. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.
- L. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:
 - 1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
 - 2. Round Mitered Elbows: Welded construction with metal thickness equal to or greater than that of ducts.
 - 3. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
 - 4. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
 - 5. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30 and 60 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.

6. Round Elbows 9 through 14 Inches in Diameter: Fabricate with gored construction, unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
7. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
8. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
9. Round Gored-Elbow Metal Thickness: Same as metal thickness or greater than that of ducts.
10. Flat-Oval Elbow Metal Thickness: Same as metal thickness or greater than that of ducts.

2.12 DOUBLE-WALL DUCT AND FITTING FABRICATION

A. Manufacturers:

1. Allied Mechanical Services.
2. Eastern Sheet Metal.
3. Foremost.
4. LaPine Metal Products.
5. McGill AirFlow Corporation.
6. SEMCO Incorporated.
7. Universal Spiral Air.
8. Zinger Sheet Metal.

B. Ducts: Fabricate double-wall insulated ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.

1. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner duct and insulation and in metal thickness specified for single-wall duct.
2. Insulation: 1-inch- thick fibrous glass, unless otherwise indicated. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components, and reduce outer shell diameter to inner duct diameter.
 - a. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.
3. Solid Inner Ducts: Use the following sheet metal thicknesses and seam construction:
 - a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral-seam construction.
 - b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral-seam construction.
 - c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral-seam construction.
 - d. Ducts 62 to 88 Inches in Diameter: 0.034 inch with standard spiral-seam construction.
4. Perforated Inner Ducts: Fabricate with 0.028-inch- thick sheet metal having 3/32-inch- diameter perforations, with overall open area of 23 percent.
5. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.

C. Fittings: Fabricate double-wall insulated fittings with an outer shell and an inner duct.

1. Solid Inner Ducts: Use the following sheet metal thicknesses:
 - a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
 - b. Ducts 35 to 58 Inches in Diameter: 0.034 inch.
 - c. Ducts 60 to 88 Inches in Diameter: 0.040 inch.

2. Perforated Inner Ducts: Fabricate with 0.028-inch- thick sheet metal having 3/32-inch- diameter perforations, with overall open area of 23 percent.

PART 3 - EXECUTION

3.1 DUCTWORK CONSTRUCTION

- A. Provide ductwork constructed in accordance with SMACNA Duct Construction Standards but no less than the static pressure classification as indicated below. Fabricate ductwork that will have less leakage than the percentage of system design air flow as indicated below.
- B. Provide ductwork constructed in accordance with SMACNA Duct Construction Standards but no less than the static pressure classification as indicated below. Fabricate ductwork that will have less leakage than the percentage of system design air flow as indicated below. Test all ductwork for leakage, unless otherwise noted, in accordance with SMACNA HVAC Air Duct Leakage Test Manual and the following.
 1. VAV Supply Air Ductwork (AHU to Terminal Units)
 - a. Duct Construction Static Pressure Class: +6-inch wg.
 - b. SMACNA Seal Class: A.
 - c. Percent Leakage of System Design Air Flow: 1/2 percent.
 - d. Testing Static Pressure: +6-inch wg.
 2. VAV Supply Air Ductwork (Terminal Units to Diffusers)
 - a. Duct Construction Static Pressure Class: +1-inch wg.
 - b. SMACNA Seal Class: C.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: No testing required.
 3. Return Air Ductwork
 - a. Duct Construction Static Pressure Class: -3-inch wg.
 - b. SMACNA Seal Class: B.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: -3-inch wg.
 4. Exhaust Air Ductwork (To roof fans)
 - a. Duct Construction Static Pressure Class: -3-inch wg.
 - b. SMACNA Seal Class: B.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: -3-inch wg.
 5. Exhaust Air Ductwork (To inline ceiling fans)
 - a. Duct Construction Static Pressure Class: -1-inch wg.
 - b. SMACNA Seal Class: C.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: No testing required.
 6. Exhaust Air Ductwork (From inline ceiling fans)
 - a. Duct Construction Static Pressure Class: +1-inch wg.
 - b. SMACNA Seal Class: C.

- c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: No testing required.
- 7. Relief Air Ductwork
 - a. Duct Construction Static Pressure Class: +1-inch wg.
 - b. SMACNA Seal Class: C.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: No testing required.
- 8. Outside Air Ductwork
 - a. Duct Construction Static Pressure Class: -1-inch wg.
 - b. SMACNA Seal Class: C.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: No testing required.
- 9. Transfer Air Ductwork
 - a. Duct Construction Static Pressure Class: -1/2-inch wg.
 - b. SMACNA Seal Class: C.
 - c. Percent Leakage of System Design Air Flow: 5 percent.
 - d. Testing Static Pressure: No testing required.

3.2 DUCT APPLICATIONS

- A. All ducts shall be galvanized steel.

3.3 DUCT INSTALLATION

- A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
- B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.
- C. Install ducts with fewest possible joints.
- D. Install fabricated fittings for changes in directions, size, and shape and for connections.
- E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.
- F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- I. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

- J. Coordinate layout with suspended ceiling, fire and smoke-control dampers, lighting layouts, and similar finished work.
- K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.
- L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.
- N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories." Firestopping materials and installation methods are specified in Division 07 Section "Penetration Firestopping."
- O. Paint interiors of metal ducts, that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.
- P. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system. Install duct mounted control dampers supplied by Temperature Control Installer.
- Q. At ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation, provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.
- R. Where indicated, install wire mesh bird screen grilles mounted in a removable frame.

3.4 DUCT CLEANLINESS REQUIREMENTS

- A. Protect duct interiors from the elements and foreign materials in accordance with the following SMACNA's "Duct Cleanliness for New Construction." Guidelines:
 - 1. Intermediate Level.

3.5 SEAM AND JOINT SEALING

- A. All ductwork shall be suitably cleaned and prepared, and sealant applied in strict accordance with manufacturer's instructions. Manufacturer's recommendations for cure time shall be followed before pressure testing is begun. Any additional paint or coatings must conform to manufacturer's specifications. Seal duct seams and joints as follows:
 - 1. Pressure Classifications Greater Than 3 Inches Water Gage: All transverse joints, longitudinal seams, and duct penetrations (SMACNA Seal Class A).

2. Pressure Classification 2 and 3 Inches Water Gage: All transverse joints and longitudinal seams (SMACNA Seal Class B).
3. Pressure Classification Less than 2 Inches Water Gage: Transverse joints only (SMACNA Seal Class C).

B. Seal ducts and leak test where indicated before external insulation is applied.

3.6 HANGING AND SUPPORTING

- A. Support ductwork with support systems indicated in SMACNA "HVAC Duct Construction Standards".
- B. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.
- C. Support vertical ducts at maximum intervals of 16 feet and at each floor.
- D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.
- E. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 1. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

3.7 CONNECTIONS

- A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- C. Louver Plenums: Fabricate of heavy gauge sheet metal material in compliance with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
 1. Fabricate with sloped bottom surface.
 2. Apply two coats of fire retardant, bitumastic waterproofing material to interior surfaces of bottom and lower half of sides.

3.8 FIELD QUALITY CONTROL

- A. Provide duct leakage testing in accordance with SMACNA HVAC Air/Duct Leakage Test Manual and prepare test reports.
- B. Disassemble, reassemble, and seal segments of the systems as required to accommodate leakage testing, and as required for compliance with test requirements.
- C. Conduct tests, in the presence of the Architect/Engineer, at static pressures equal to the maximum design pressure of the system or the section being tested. If pressure classifications are not indicated, test entire

system at the maximum system design pressure. Do not pressurize systems above the maximum design operating pressure. Give 3 days' advanced notice for testing.

- D. Remake leaking joints as required and apply sealants to achieve specified maximum allowable leakage.
- E. Seal and leak test externally insulated ducts prior to insulation installation.
- F. Provide Leakage Testing on ductwork located in inaccessible locations (underslab, in walls and chases, etc.) before final covering is performed.

END OF SECTION 23 3113

SECTION 23 3300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Manual volume dampers.
2. Fire dampers.
3. Combination fire and smoke dampers.
4. Flange connectors.
5. Duct silencers.
6. Turning vanes.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Flexible ducts.

B. Related Sections:

1. Division 23 Section "Instrumentation and Control for HVAC" for motorized control dampers and damper actuators.
2. Division 23 Section "HVAC Gravity Ventilators" for roof-mounted ventilator caps.
3. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.2 ACTION SUBMITTALS

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

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.3 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2D finish for concealed applications and No. 4 for exposed applications.
- D. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- G. 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 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Flexmaster U.S.A., Inc.
 - d. Greenheck.
 - e. McGill AirFlow LLC.
 - f. METALAIRE, Inc.
 - g. Nailor Industries Inc.
 - h. Pottorff.
 - i. Ruskin Company.
 - j. Trox USA Inc.
 - k. Vent Products Company, Inc.

2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Hat-shaped, galvanized-steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized-steel, 0.064 inch thick.
6. Blade Axles: Galvanized steel.
7. Bearings:
 - a. Oil-impregnated bronze or molded synthetic.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.

B. Damper Hardware:

1. Locking manual quadrant calibrated to show damper position.
2. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
3. Include center hole to suit damper operating-rod size.
4. Include elevated platform for insulated duct mounting.

2.3 FIRE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. Pottorff.
10. Ruskin Company.
11. Vent Products Company, Inc.
12. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Static; rated and labeled according to UL 555 by an NRTL.

C. Fire Rating: 1-1/2 hours.

- D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
 - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.4 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance Inc.; a division of Mestek, Inc.
 - 2. Cesco Products; a division of Mestek, Inc.
 - 3. Greenheck Fan Corporation.
 - 4. Nailor Industries Inc.
 - 5. Pottorff.
 - 6. Ruskin Company.
- B. Type: Static; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Fire Rating: 1-1/2 hours.
- D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.
- F. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- G. Leakage: Class II.
- H. Rated pressure and velocity to exceed design airflow conditions.
- I. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application.
- J. Damper Motors: Two-position action.

- K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 7. Electrical Connection: 115 V, single phase, 60 Hz.

2.5 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Nexus PDQ; Division of Shilco Holdings Inc.
 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.6 DUCT SILENCERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Industrial Noise Control, Inc.
 2. McGill AirFlow LLC.
 3. Ruskin.
 4. Vibro-Acoustics.
 5. Aerosonics
 6. Commercial Acoustics
 7. Dynasonics
 8. Vibron
 9. Semco
 10. VAW
 11. Price-HVAC

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. The dynamic insertion loss in dB for silencers shall not be less than that shown on the Duct Silencer Schedule at the face air velocity of +1,000 fpm (+ indicates airflow in the same direction as attenuation).
5. Duct silencers shall not produce self-noise power levels in dB re 10^{-12} watts that exceed those shown on the Duct Silencer Schedule.
6. Duct silencers static pressure drop shall not exceed those indicated on the duct silencer schedule for the scheduled airflow velocity and location shown.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.034 inch thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.052 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch- diameter perforations.

G. Connection Sizes: Match connecting ductwork unless otherwise indicated.

H. Principal Sound-Absorbing Mechanism:

1. Dissipative type with fill material.
 - a. Fill Material: Inert, mold-resistant, and vermin- and moisture-proof fibrous material.
2. Lining: Mylar.

I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Lock form and seal or continuously weld joints.

J. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.

K. Source Quality Control: Test according to ASTM E 477.

2.7 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. METALAIRE, Inc.
 - 4. SEMCO Incorporated.
 - 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.8 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2. Cesco Products; a division of Mestek, Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Flexmaster U.S.A., Inc.
 - 5. Greenheck Fan Corporation.
 - 6. McGill AirFlow LLC.
 - 7. Nailor Industries Inc.
 - 8. Pottorff.
 - 9. Ruskin.
 - 10. Ventfabrics, Inc.
 - 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
- C. Rectangular Ductwork Applications:
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.

- b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
- c. Access Doors up to 24 by 24 Inches: Three hinges and two compression latches with outside and inside handles.

D. Round Ductwork Applications:

- 1. Sandwich Type for Uninsulated Ductwork: Oval shaped inner and outer plates connected by bolt fasteners and compression springs with hand knobs for compression fit in duct sidewall.
 - a. Provide doors with insulated inner plate for installation in pre-insulated double wall ductwork.
- 2. Rectangular Type for Insulated Ductwork: Same as specified for rectangular ductwork application with field or factory installed rectangular tap.

E. Pressure Relief Access Door:

- 1. Door and Frame Material: Galvanized sheet steel.
- 2. Door: Single wall for uninsulated duct applications and double wall with insulation fill for insulated duct applications with metal thickness applicable for duct pressure class.
- 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
- 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: 1-inch- thick, fibrous-glass or polystyrene-foam board.
- 9. Factory set at pressure settings indicated below:
 - a. Spring clips rated at 3-inch wg negative and 5-inch wg positive for VAV applications.
 - b. Spring clips rated at 2-inch wg negative and 3-inch wg positive for constant volume systems.

2.9 FLEXIBLE CONNECTORS

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

- 1. Ductmate Industries, Inc.
- 2. Duro Dyne Inc.
- 3. Ventfabrics, Inc.
- 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

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 2 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.

- F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
 2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 3. Service Temperature: Minus 50 to plus 250 deg F.

2.10 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct (Type F-1): UL 181, Class 1, acoustically rated, woven fiberglass fabric with flame resistant coated core supported by helically wound, spring-steel wire; fibrous-glass insulation (R-4.2); bi-directional reinforced metallized vapor-barrier film.
1. Basis-of-Design Product: Subject to compliance with requirements, provide Themaflex Model M-KC or comparable product by the following:
 - a. Flexmaster U.S.A., Inc. Flexmaster Type 6 or approved equivalent.
 2. Positive Pressure Rating: 16-inch wg positive for sizes 4 to 10 Inches, 10-inch wg positive for sizes 12 to 16 Inches.
 3. Negative Pressure Rating: 2.0-inch wg negative for sizes 4 to 16 Inches.
 4. Maximum Air Velocity: 6000 fpm.
 5. Temperature Range: Minus 20 to plus 250 deg F.
 6. Insulation R-value: R-4.2
- B. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action or nylon strap in sizes 3 through 18 inches, to suit duct size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.
- B. Install duct accessories of galvanized-steel materials in galvanized-steel ducts.
- C. Install turning vanes in all square or rectangular 90 degree elbows.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
1. Install steel volume dampers in steel ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install fire and fire/smoke dampers according to UL listing.

- G. Connect ducts to duct silencers rigidly.
 - 1. Do not locate duct silencers within one duct diameter from fan discharge/intake openings, elbows, or takeoffs.
 - 2. When elbows precede duct silencer by less than 3 duct widths (as measured in the elbow plane), splitters should be parallel to the plane of the elbow turn.
- H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. At outdoor-air intakes and mixed-air plenums.
 - 3. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 4. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - a. For fire or smoke dampers located in ducts with no other air path between AHU outlet and damper, install pressure relief access doors upstream of fire or smoke dampers.
 - b. For fire or smoke dampers located in ducts with high velocity and no other air path between AHU outlet and damper, install pressure relief access doors upstream and down stream of fire or smoke dampers.
 - c. For fire or smoke dampers located in ducts with high velocity and other air paths between AHU outlet and damper, install pressure relief access doors down stream of fire or smoke dampers.
 - 5. At each change in direction and at maximum 50-foot spacing.
 - 6. Upstream and downstream from turning vanes.
 - 7. Upstream or downstream from duct silencers.
 - 8. Upstream and downstream of duct mounted airflow monitor devices.
 - 9. At duct mounted smoke detectors.
 - 10. Control devices requiring inspection.
 - 11. Elsewhere as indicated.
- I. Access Door Minimum Sizes:
 - 1. Two-Hand or Inspection Access: 12 by 12 inches.
 - 2. Head and Shoulders Access: 20 by 16 inches.
 - 3. Body Access: 24 by 24 inches.
 - 4. For ducts less than 12 by 12 inches
- J. Install flexible connectors to connect ducts to equipment.
- K. Install flexible ducts as follows:
 - 1. Install flexible ducts at accessible concealed locations only.
 - 2. Connect terminal units to high velocity supply ducts with maximum 18-inch lengths of flexible duct Type F-1, clamped or strapped in place. Flexible ducts are for alignment purposes only. Do not use flexible ducts to change directions.

3. Connect diffusers to ducts directly or with maximum 36-inch lengths of flexible duct Type F-1, clamped or strapped in place. Flexible ducts are for alignment purposes only. Do not use flexible ducts to change directions.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 3300

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SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Centrifugal roof ventilators.
 - 2. Axial roof ventilators.
 - 3. Upblast propeller roof exhaust fans.
 - 4. In-line centrifugal fans.

1.2 PERFORMANCE REQUIREMENTS

- A. Operating Limits: Classify according to AMCA 99.

1.3 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.8 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Engineering & Mfg. Corp.
 - 2. Aerovent; a Twin City Fan Company
 - 3. Greenheck.
 - 4. Loren Cook Company.
 - 5. Penn-Barry.
- B. Description: Direct- driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
 - 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Drive Assembly: Resiliently mounted to housing, with the following features:

1. Motor: ECM with integral speed control.
2. Fan and motor isolated from exhaust airstream.

F. Accessories:

1. Variable-Speed Controller (Direct Drive Only): Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing with mounting flange.
2. Overall Height: As scheduled.
3. Pitch Mounting: Manufacture curb for roof slope.

2.2 AXIAL ROOF VENTILATORS

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

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan Company.
3. Greenheck.
4. JencoFan; Div. of Breidert Air Products.
5. Loren Cook Company.
6. New York Blower Company (The).
7. Penn Ventilation.

B. Description: Direct- or belt-driven axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

C. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.

1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheel: Aluminum or Steel hub and blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.

F. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
 2. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
 4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Self-flashing with mounting flange.
 2. Overall Height: As scheduled.
 3. Pitch Mounting: Manufacture curb for roof slope.

2.3 UPBLAST PROPELLER ROOF EXHAUST FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acme Engineering & Mfg. Corp.
 2. Aerovent; a Twin City Fan Company.
 3. Greenheck.
 4. JencoFan; Div. of Breidert Air Products.
 5. Loren Cook Company.
 6. New York Blower Company (The).
 7. Penn Ventilation.
- B. Description: Direct- or belt-driven propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel or [aluminum, containing galvanized-steel or aluminum butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
1. Damper Rods: Steel with bronze or nylon bearings.
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- D. Fan Wheel: Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to housing; weatherproof housing of same material as fan housing with the following features:
1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 2. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 4. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.
- F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Self-flashing with mounting flange.

2. Overall Height: As scheduled.
3. Pitch Mounting: Manufacture curb for roof slope.

2.4 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acme Engineering & Mfg. Corp.
 2. Aerovent; a Twin City Fan Company
 3. Greenheck.
 4. Loren Cook Company.
 5. Penn -Barry.
 6. S & P.
- B. Description: In-line, direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- C. Housing: Square galvanized steel or aluminum with inlet and outlet flanges, removable access panels, and support brackets adaptable to floor, side wall, or ceiling mounting.
- D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Fan Wheels: Aluminum, welded to aluminum hub.
- F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 4. Vibration Isolators:
 - a. Type: Elastomeric hangers.
 - b. Static Deflection: 1 inch.

2.5 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- B. Enclosure Type: Totally enclosed, fan cooled.

2.6 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support suspended circulation fans from structure using structural steel framing. Install factory furnished field installed control components.
- C. Secure roof-mounted ventilators to roof curbs with cadmium-plated hardware.
- D. Secure wall-mounted ventilators to building structure with cadmium-plated fasteners.
- E. Support suspended ceiling mounted units from structure using threaded steel rods and vibration isolators.
- F. Install units with clearances for service and maintenance.
- G. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 KILN EXHAUST VENTILATION SYSTEM INSTALLATION

- A. Install system components level and plumb in accordance with manufacturer's instructions.
- B. Install units with clearances for service and maintenance.
- C. Field cut flexible hose to shortest length permissible.
- D. Provide Type B double wall vent duct through roof with roof thimble and gooseneck end bird screen.

3.3 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
1. Verify that shipping, blocking, and bracing are removed.
 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 3. Verify that cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature-control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.5 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION 23 3423

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SECTION 23 3600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes shutoff single-duct air terminal units.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.4 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- B. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers:
 - 1. Anemostat; a Mestek Company.
 - 2. Johnson Controls
 - 3. Krueger.
 - 4. Nailor Industries of Texas Inc.
 - 5. Price Industries.

6. Titus.
 7. Trane.
 8. Tuttle & Bailey.
- B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- C. Casing: Steel or aluminum.
1. Casing Lining: Minimum 1/2-inch- thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive. Cover liner with nonporous foil and seal edges.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Velocity Sensors: Multipoint array with velocity sensors in air inlet.
- E. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
1. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
- F. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 2. Damper Position: Normally open.
- G. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed with minimum 4 row coil.
- H. Direct Digital Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation and Control for HVAC."
1. The terminal unit controller flow transducer and damper actuators shall be supplied by the controls contractor for factory installation on the terminal unit. All controls components shall be mounted and wired per the control contractor's documentation. When required the control components shall be installed within a controls enclosure provided by the terminal manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

- B. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- C. Install piping adjacent to air terminal units to allow service and maintenance.
 - 1. Offset piping at coils to allow for coil removal.
- D. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve, shutoff valve, drain valve, and union or flange.
 - 1. Provide coil bypass during flushing activities.
- E. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."
- F. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- H. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing air terminal units, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 3600

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SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes diffusers, registers, and grilles.
- B. Related Sections:
 - 1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following:
 - 1. Grilles, Registers and Diffusers:
 - a. Anemostst.
 - b. Krueger.
 - c. Price.
 - d. Tuttle and Bailey.
 - e. Titus.
 - f. Nailor.

2.2 DIFFUSERS

- A. General: Provide manufacturer's standard diffusers where shown; of size, shape, capacity and type as listed on diffuser schedule, with accessories and finishes as indicated.
 - 1. Diffuser Faces:
 - a. Square: Square housing; core of square concentric louvers; square or round duct connection.

- b. Rectangular: Rectangular housing; core of rectangular concentric louvers; square or round duct connection.
 - c. Panel: Square or rectangular housing extended to form panel to fit in ceiling system module; core of square or rectangular concentric louvers; square or round duct connection.
- 2. Diffuser Mountings
 - a. Surface: Diffuser housing at duct, wall or ceiling surface with gasketed perimeter flange.
 - b. Lay-In: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.

2.3 GRILLES AND REGISTERS

- A. General: Provide manufacturer's standard grilles and registers where shown; of size, shape, capacity and type as listed on schedule, with accessories and finishes as indicated.
 - 1. Register and Grille Materials:
 - a. Steel Construction: Manufacturer's standard stamped sheet steel frame and adjustable blades.
 - b. Aluminum Construction: Manufacturer's standard extruded aluminum frame and adjustable blades.

2.4 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 DIFFUSER, REGISTER, AND GRILLE INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts.
- D. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 3713

SECTION 23 3723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following types of roof-mounting intake and relief ventilators:
 - 1. Roof hoods.
- B. Related Sections include the following:
 - 1. Division 08 Section "Louvers and Vents" for ventilator assemblies provided as part of the general construction.
 - 2. Division 23 Section "HVAC Power Ventilators" for roof-mounting exhaust fans.

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MATERIALS

- A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B 209, Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 zinc coating, mill phosphatized.
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel, unless otherwise indicated. Do not use metals that are incompatible with joined materials.
 - 1. Use types and sizes to suit unit installation conditions.
- E. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.3 ROOF HOODS

A. Manufacturers:

1. Acme Engineering & Mfg. Corp.
2. Aerovent; a Twin City Fan company.
3. Greenheck.
4. JencoFan.
5. Loren Cook Company.
6. Penn Ventilation.
7. Ruskin.

B. Factory fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 5-6 and 5-7.

C. Materials: Galvanized-steel sheet, minimum 0.064-inch- thick base and 0.040-inch- thick hood; suitably reinforced.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-(40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch(40-mm) wood nailer. Size as required to fit roof opening and ventilator base. Provide with level top and bottom to match roof slope.

1. Configuration: Self-flashing with mounting flange.
2. Overall Height: Refer to drawing detail.

E. Bird Screening: Galvanized-steel, 1/2-inch- square mesh, 0.041-inch wire.

F. Insulation: Insulate inside bottom of ventilator roof.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Secure gravity ventilators to roof curbs with cadmium-plated hardware. Use concealed anchorages where possible.

C. Install gravity ventilators with clearances for service and maintenance.

D. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Division 07 Section "Joint Sealants" for sealants applied during installation.

E. Label gravity ventilators according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

F. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

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- G. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories.

END OF SECTION 23 3723

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SECTION 23 5216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube condensing boilers, trim, and accessories for generating hot water.

1.2 ACTION SUBMITTALS

- A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASME Compliance:
 - 1. Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
 - 2. Install, maintain, operate, and test controls and safety devices to comply with CSD-1.
- C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.6 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Fire-Tube Condensing Boilers:
 - a. Leakage and Materials: 10 years from date of Substantial Completion.
 - b. Heat Exchanger Damaged by Thermal Stress and Corrosion: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FIRE-TUBE CONDENSING BOILERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings (AERCO Benchmark) or comparable product by the following:
 - 1. Lochinvar. (Crest Model)
 - 2. Patterson Kelly.
- B. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
- C. Heat Exchanger: Stainless steel fire tube.
- D. Pressure Vessel: Carbon steel with welded heads and tube connections.
- E. Burner: Natural gas, forced draft.
- F. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
 - 1. Motors: Comply with requirements specified in Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- G. Gas Train: Combination gas valve with manual shutoff and pressure regulator complete with controls and safety devices to comply with CSD-1.
- H. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.

I. Casing:

1. Jacket: Manufacturer's standard with snap-in or interlocking closures.
2. Control Compartment Enclosures: NEMA 250, Type 1A.
3. Finish: Manufacturer's standard protective finish.
4. Insulation: Minimum 2-inch- thick insulation surrounding the heat exchanger.
5. Combustion-Air Connections: Inlet and vent duct collars.
6. Mounting base to secure boiler.

J. Characteristics and Capacities:

1. Heating Medium: Hot water.
2. Design Water Pressure Rating: 160 psig.
3. Minimum Thermal Efficiency: 92 percent at full fire and 99% with return water temperature at 90 deg F.

2.2 CONTROLS

A. Boiler operating controls shall include the following devices and features:

1. Control transformer.
2. Set-Point Adjust: Set points shall be adjustable.
3. Sequence of Operation: Microprocessor to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F outside-air temperature, set supply-water temperature at 130 deg F; at 60 deg F outside-air temperature, set supply-water temperature at 90 deg F.
4. Sequence of Operation: Microprocessor to control burner firing rate to reset supply-water temperature inversely with outside-air temperature with setpoint received from BMS.
 - a. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
 - b. Include capability to remove boiler or boilers from system without effecting remaining boiler system operations

B. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

1. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design temperature.
2. Low-Water Cutoff Switch: Shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.

C. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

1. Hardwired Points:
 - a. Monitoring: On/off status, common trouble alarm low water level alarm.
 - b. Control: On/off operation, hot water supply temperature set-point adjustment.

2.3 ELECTRICAL POWER

- A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.
- B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
 - 1. House in NEMA 250, Type 1 enclosure.
 - 2. Wiring shall be numbered and color-coded to match wiring diagram.

2.4 VENTING KITS

- A. Complete venting system as indicated for combustion air intake and exhaust venting in accordance with boiler manufacturer's requirements. Include terminals, thimbles, adapters, couplings, and sealant.
 - 1. Vent Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
 - 2. Combustion-Air Intake: Complete system, PVC pipe, vent terminal with screen, inlet air coupling, and sealant.

2.5 SOURCE QUALITY CONTROL

- A. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- B. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.
 - 1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- B. Examine mechanical spaces for suitable conditions where boilers will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

- A. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
- B. Install gas-fired boilers according to International Fuel Gas Code and NFPA 54.
- C. Assemble and install boiler trim.
- D. Install electrical devices furnished with boiler but not specified to be factory mounted.
- E. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- D. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
- E. Connect hot-water piping to supply- and return-boiler tapings with shutoff valve and union or flange at each connection.
- F. Install piping from safety relief valves to nearest floor drain.
- G. Boiler Venting:
 - 1. Install venting kit for exhaust venting and combustion-air intake.
- H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Arrange with the Authority having jurisdiction for inspection and certification of boiler installation. Installer shall be responsible for any required fees.
- B. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

E. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

3.5 DEMONSTRATION

- A.** Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 5216

SECTION 23 6426.13 - AIR-COOLED, ROTARY-SCREW WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Chiller compressor with air cooled condensors..

1.3 DEFINITIONS

- A. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
- B. DDC: Direct digital control.
- C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
- D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and referenced to AHRI standard rating conditions.
- E. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
- F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by AHRI 550/590 and intended for operating conditions other than AHRI standard rating conditions.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
 - 2. Performance at AHRI standard conditions and at conditions indicated.
 - 3. Performance at AHRI standard unloading conditions.
 - 4. Minimum evaporator flow rate.
 - 5. Refrigerant capacity of chiller.
 - 6. Oil capacity of chiller.
 - 7. Fluid capacity of evaporator.

8. Characteristics of safety relief valves.
9. Minimum entering condenser-air temperature.
10. Maximum entering condenser-air temperature.
11. Performance at varying capacities with constant-design, entering condenser-air temperature. Repeat performance at varying capacities for different entering condenser-air temperatures from design to minimum in 10 deg F increments.

B. Shop Drawings:

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

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For certification required in "Quality Assurance" Article.
- B. Seismic Qualification Data: Certificate, for chillers, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Source quality-control reports.
- D. Field Test Reports: Include startup service reports.
- E. Sample Warranty: For AHRI special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. AHRI Certification: Certify chiller according to AHRI 590 certification program(s).
- B. AHRI Rating: Rate chiller performance according to requirements in AHRI 550/590.
- C. ASHRAE Compliance:
 1. ASHRAE 15 for safety code for mechanical refrigeration.
 2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.
- E. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
- F. Comply with NFPA 70.
- G. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Ship chillers from the factory fully charged with refrigerant.
- B. Ship each oil-lubricated chiller with a full charge of oil.
 - 1. Ship oil factory installed in chiller.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
 - 1. Extended warranties include, but are not limited to, the following:
 - a. Complete chiller including refrigerant and oil charge.
 - b. Complete compressor and drive assembly including refrigerant and oil charge.
 - c. Refrigerant and oil charge.
 - d. Parts and labor.
 - e. Loss of refrigerant charge for any reason.
 - 2. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."
- B. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
- C. Performance Tolerance: Comply with the following in lieu of AHRI 550/590:
 - 1. Allowable Capacity Tolerance: Zero percent.

2. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

2.2 SOURCE QUALITY CONTROL

- A. Perform functional tests of chillers before shipping.
- B. Factory run test each air-cooled chiller with water flowing through evaporator.
- C. Factory performance test air-cooled chillers, before shipping, according to AHRI 550/590.
 1. Test the following conditions:
 - a. Design conditions indicated.
 - b. Reduction in capacity from design to minimum load in steps of 10 with condenser air at design conditions.
 - c. At four point(s) of varying part-load performance to be selected by Owner at time of test.
 2. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
- D. Factory test and inspect evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- E. For chillers located indoors, rate sound power level according to AHRI 575.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine chillers before installation. Reject chillers that are damaged.
- B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.
 1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CHILLER INSTALLATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
- C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

- D. Install chillers on support structure indicated.
- E. Equipment Mounting:
 - 1. Install chillers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-in-Place Concrete."
 - 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 23 0548 "Vibration and Seismic Controls for HVAC."
 - 3. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- F. Maintain manufacturer's recommended clearances for service and maintenance.
- G. Charge chiller with refrigerant and fill with oil if not factory installed.
- H. Install separate devices furnished by manufacturer and not factory installed.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 23 2113 "Hydronic Piping," Section 23 2116 "Hydronic Piping Specialties," and Section 23 2300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to chiller to allow service and maintenance.
- C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, and drain connection with valve. Make connections to chiller with a flange.
- D. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
- E. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
 - 3. Verify that pumps are installed and functional.
 - 4. Verify that thermometers and gages are installed.
 - 5. Operate chiller for run-in period.
 - 6. Check bearing lubrication and oil levels.
 - 7. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
 - 8. Verify proper motor rotation.

9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
 10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
 11. Verify and record performance of chiller protection devices.
 12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
- B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
- C. Prepare test and inspection startup reports.

3.5 DEMONSTRATION

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

END OF SECTION 23 6426.13

SECTION 23 7313 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes modular indoor air handling units.

1.2 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit indicated.
 - 1. Unit dimensions and weight.
 - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.
 - 3. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated.
 - b. Certified fan-sound power ratings.
 - c. Fan construction and accessories.
 - d. Motor ratings, electrical characteristics, and motor accessories.
 - 4. Certified coil-performance ratings with system operating conditions indicated.
 - 5. Dampers, including housings and linkages.
 - 6. Filters with performance characteristics.
 - 7. Wiring diagrams.

1.3 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filters: Two sets for each air-handling unit. One during construction and new set when testing is complete.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver air-handling units as a factory-assembled unit to the extent allowable by shipping limitations, with protective covering.
- B. Lift and support units with the manufacturer's designated lifting or supporting points.
- C. Disassemble and reassemble units as required for movement into the final location following manufacturer's written instructions.

1.8 COORDINATION

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier.
 - 2. Trane.
 - 3. JCI.
 - 4. Daikin

2.2 MANUFACTURED UNITS

- A. General Description: Provide factory assembled modular air-handling units comprised of dimensionally compatible casing modules which house all system components; including fans, motor and drive assembly, access sections, coils, plenums, filters, drain pans, and dampers.

2.3 UNIT CASINGS

- A. General Fabrication Requirements for Casings: Construct of structural steel framing with removable 2" thick double-wall insulated panels; all galvanized steel materials.
1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 2. Casing Joints: Sheet metal screws or pop rivets.
 3. Sealing: Seal all joints with water-resistant sealant.
 4. Factory Finish for Casings: Manufacturer's standard finish.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Casing Walls: Galvanized solid sheet steel with integral seals at all framing element contact surfaces, and secured to frame with corrosion resistant fastening system configured to minimized thermal bridging to air side of unit.
- C. Casing Insulation and Adhesive:
1. Materials: ASTM C 1071.
 2. Location and Application: Encased between outside and inside casing.
- D. Inspection and Access Panels and Access Doors:
1. Panel and Door Fabrication: Formed and reinforced, double-wall insulated panels of same materials and thicknesses as casing.
 2. Inspection and Access Panels:
 - a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
 3. Access Doors:
 - a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Fabricate windows in doors where indicated of safety glass with rubber seals.
 - d. Door Size: Minimum 18 inches wide by full height of unit casing up to a maximum height of 72 inches.
 4. Locations and Applications:
 - a. Fan Section: Doors and inspection and access panels.
 - b. Access Section: Doors.
 - c. Coil Section: Doors and inspection and access panels..
 - d. Damper Section: Doors.
 - e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
 - f. Air Blender Section: Doors.
 - g. Mixing Section: Doors.

5. Service Light: Factory wired 100-W equivalent LED in a vaporproof fixture with switched junction box located outside of unit.
 - a. Locations: As indicated on schedule.

E. Condensate Drain Pans:

1. Fabricated with minimum one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and to direct water toward drain connection.
 - a. Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - b. Depth: A minimum of 2 inches deep.
2. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate outside of unit with threaded nipple and cap on one end of pan.
3. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
4. Locations:
 - a. Cooling Coil Sections.

F. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

G. Floor Openings: All duct connections or control dampers in the floor of the units shall be covered with painted heavy gauge steel bar grating bolted in place, to prevent people and large objects from passing through the unit floor into the ductwork.

2.4 FAN, DRIVE, AND MOTOR SECTION

A. Fan Mounting: Mount fan and motor on a structural steel frame mounted on manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch sized to eliminate fan vibration and noise. Provide flexible duct connecting between unit casing and fan outlet.

B. Fan Shaft Bearings:

1. Grease-Lubricated, Bearings: Self-aligning, pillow-block type with 2-piece, cast-iron housing with grease lines extended to outside unit and a rated life of 200,000 hours according to ABMA.

C. Plenum Fans:

1. Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
2. Fan Wheels: Single-width, single-inlet, plenum fan wheel.
3. Drives: Direct or belt drive.
4. Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.

D. Centrifugal Fans:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 - a. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.

- 1) Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - 2) Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
 2. Airfoil, Centrifugal Fan Wheels: Double-width-double-inlet construction with smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
 3. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with manufacturer's standard service factor based on fan motor.
 - a. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - b. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 - c. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
 4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.
- E. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
1. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 3. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
- F. Variable Frequency Drives: Provided by Equipment Manufacturer. Refer to Division 23 Section "Instrumentation and Controls for HVAC."
- G. Variable Frequency Drives: Provided with unit.
1. The variable frequency drives (VFD) shall be designed specifically for use in Heating, Ventilation, and Air Conditioning (HVAC) applications in which speed control of the motor can be applied. The VFD, including all factory installed options, shall have UL & CSA approval.
 2. VFD's shall include communications capability with DDC BMS via built-in interface card. Coordinate communications type with BMS.
 3. Unit manufacturer shall furnish variable frequency drive (VFD) for each fan motor.
 4. Built-in VFD Protection:
 - 1) 5% DC Choke for harmonic protection.
 - 2) Standard RFI Filter: Ensures that EMC/RFI requirements are met.
 - 3) Fire Mode for safe operation.
 - 4) Enclosure Class: NEMA 1, NEMA 12 or NEMA 3R as required by application.
 - 5) Motor switch ride-through for easy, fault-free maintenance.
 - 6) Overvoltage trip and undervoltage trip protection.
 - 7) Ground fault protection.
 - 8) Mains and motor phase supervisions.

- 9) Overcurrent and unit overtemperature protection.
- 10) Motor overload, motor stall and motor underload protection.
- 11) Short-circuit protection of +24V and +10V reference voltage.
- b. Bypass Options:
 - 1) Fused disconnect with no bypass.
 - 2) Manual bypass.
 - 3) Automatic bypass.
 - 4) Contactor.

2.5 COIL SECTION

A. General Requirements for Coil Section:

- 1. Comply with ARI 410.
- 2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- 3. Coils shall not act as structural component of unit.

B. Connections: Provide factory installed piping connection points outside of unit casing and ready for field connections; with casing penetration points sealed against leakage for unit's rated pressure.

C. Water Coils: Drainable, rigidly supported across the full face of the coil, and pitched to allow drainage.

- 1. Fins: Aluminum, constructed from flat plate with belled collars for tubes. Fins shall be bonded to tubes by mechanically expanding copper tubes.
- 2. Tubes: Seamless copper.
- 3. Coil Casing: Galvanized steel.
- 4. Headers: Steel or cast iron, with connections for drain valve and air vent and threaded piping connections.
- 5. Rows: Cooling water coils shall be 6 row minimum.

2.6 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:

- 1. Comply with NFPA 90A.
- 2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
- 3. Provide filter holding frames arranged for flat or angular orientation, with access doors. Filters shall be removable from one side or lifted out from access plenum.

B. Prefilters: Extended-surface, disposable panel filters:

- 1. Factory-fabricated, dry, extended-surface type.
- 2. Thickness: 2 inches.
- 3. Arrestance (ASHRAE 52.1): 90.
- 4. Merv (ASHRAE 52.2): 8.
- 5. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting wire grid.
- 6. Media-Grid Frame: Nonflammable cardboard.

7. Mounting Frames: Galvanized steel, with gaskets and fasteners.
- C. Filters: Extended-surface, non-supported media filters:
1. Factory-fabricated, dry, extended-surface, self-supporting type.
 2. Arrestance (ASHRAE 52.1): 98.
 3. Merv (ASHRAE 52.2): 13.
 4. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.
 5. Filter-Media Frame: Galvanized steel.
 6. Mounting Frames: Galvanized steel, with gaskets and fasteners, with space for prefilter.
 7. 3-1/2-inch- diameter, diaphragm-actuated dial in metal case.
 8. Vent valves.
 9. Black figures on white background.
 10. Front recalibration adjustment.
 11. 2 percent of full-scale accuracy.
 12. Range: 0- to 2.0-inch wg.
 13. Prefilter Range: 0- to 0.5-inch wg.
 14. Final Filter Range: 0- to 1.0-inch wg.
 15. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch tubing, and 2- or 3-way vent valves.

2.7 DAMPERS

- A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.
- B. Mixing Box Outdoor- and Return-Air Dampers: Galvanized-steel or aluminum dampers mechanically fastened to cadmium-plated steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
1. For combination filter and mixing box section, include cabinet support members to hold 2-inch-thick, pleated, flat, throwaway filters.
- C. Economizer Outdoor, Relief and Return Air Dampers: Low-leakage, galvanized-steel or aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals with cadmium-plated steel operating rod. Leakage rate shall not exceed 5 cfm/sq. ft. at 1-inch wg.

2.8 SOURCE QUALITY CONTROL

- A. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
- B. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."

- C. Water Coils: Factory tested to 150 psig according to ARI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Equipment Mounting: Install air-handling units on concrete bases. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 23 "Common Work Results for HVAC".
- B. Equipment Mounting: Install air-handling units on structural-steel support frame. Secure frame to floor and unit to frame.
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

3.2 MOTOR GROUNDING

- A. Provide factory installed shaft grounding ring at each three phase motor utilizing a variable frequency controller. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- B. Provide copper braided grounding strap between motor and metallic conduit for motors controlled by variable frequency motor controllers.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air-handling unit to allow service and maintenance.
- C. Connect to condensate drain pans and extend to nearest floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- D. Hydronic Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install calibrated balancing valve and union or flange at each coil return connection.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, test coils and connections for leaks.
 - 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations.
 - 5. Verify that bearings and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Verify that dampers open and close, and maintain minimum outdoor-air setting.
 - 7. Comb coil fins for parallel orientation.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel.
 - 2. For belt driven units, replace fan and motor pulleys as required to achieve design conditions.
 - 3. Measure and record motor electrical values for voltage and amperage.
 - 4. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new clean filters.

3.8 DEMONSTRATION

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

END OF SECTION 23 7313

SECTION 23 8126 – SPLIT SYSTEM AIR CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

1.2 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. LEED Submittals:
 - 1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
- C. Shop Drawings: Diagram power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.
- B. Warranty: Special warranty specified in this Section.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.6 COORDINATION

- A. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations.

1.7 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.
 - 2. Warranty Period: Two 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. Enviromaster International.
 - 2. Carrier Air Conditioning; Div. of Carrier Corporation.
 - 3. Friedrich Air Conditioning Company.
 - 4. Modine.
 - 5. Mitsubishi Electronics America, Inc.; HVAC Division.
 - 6. Sanyo Fisher (U.S.A.) Corp.
 - 7. Trane.
 - 8. JCI/York.
 - 9. Airedale.

2.2 CEILING-MOUNTING, EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
 - 1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
 - 2. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
- C. Fan: Direct drive, centrifugal fan, with power-induced outside air, and integral condensate pump.
- D. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
- E. Filters: Permanent, cleanable.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

- A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
- B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Fan: Aluminum-propeller type, directly connected to motor.
- E. Motor: Permanently lubricated, with integral thermal-overload protection.
- F. Low Ambient Kit: Permits operation down to 32 deg F.
- G. Mounting Base: Polyethylene.
- H. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ACCESSORIES

- A. Control equipment and sequence of operation are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
- B. Thermostat: Wall mounted hard wired, functioning to remotely control compressor and evaporator fan, with the following features:
 - 1. Compressor time delay.
 - 2. 24-hour time control of system stop and start.
 - 3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
 - 4. Fan-speed selection, including auto setting.
- C. Condensate Pump: Provide condensate mini-pump for condensate disposal if needed.
- D. Safety: High condensate pan water level shutdown.
- E. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
 - 1. Minimum Insulation Thickness: 1/2 inch thick.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb.
- B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install ground-mounting, compressor-condenser components on 4-inch- thick, reinforced concrete base; 4 inches larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.
- D. Install ground-mounting, compressor-condenser components on polyethylene mounting base. Anchor units to base with removable, cadmium-plated fasteners.
- E. Install roof-mounting compressor-condenser components on polyethylene mounting base. Anchor units to base with removable, cadmium-plated fasteners.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping." Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
 - 2. Connect to condensate drain pans and extend to condensate pump and then to nearest floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply and return ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

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. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 8126

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SECTION 23 8233 - CONVECTORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Hydronic finned-tube radiators.

1.2 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Color Samples for Initial Selection: For units with factory-applied color finishes.
- D. Color Samples for Verification: For each type of exposed finish required.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATORS

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

2. Rittling, a div. of Hydro-Air Components.
 3. Sigma.
 4. Sterling.
 5. Trane.
 6. Vulcan.
- B. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
- C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One tube end shall be belled.
- D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
- E. Front Panel: Minimum 0.0781-inch- thick steel.
- F. Wall-Mounting Back Panel: Minimum 0.0329-inch- thick steel, full height, with full-length channel support for front panel without exposed fasteners.
- G. Floor-Mounting Pedestals: Conceal insulated piping at maximum 36-inch spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.
- H. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
- I. Finish: Baked finish in manufacturer's standard color as selected by Architect.
- J. Damper: Knob-operated internal damper at enclosure outlet.
- K. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
- L. Enclosure Style: Sloped top.
1. Bottom Inlet: Open bottom.
 2. Top Outlet Grille: Punched louver; painted to match enclosure.
- M. Accessories:
1. Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

2.2 HOT-WATER CONVECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Modine.
 2. Rittling, a div. of Hydro-Air Components.
 3. Sigma.
 4. Sterling.
 5. Trane.

6. Vulcan.
 - B. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum 100 psig.
 - C. Front and Top Panel: Minimum 0.0677-inch- thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
 1. Recessed Cabinets: One-piece front panel, with 4-side gasketed overlap.
 - D. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum 36-inch spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
 - E. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.
 - F. Insulation: 1/2-inch- thick, fibrous glass on inside of the back of the enclosure.
 - G. Finish: Baked-enamel finish in manufacturer's standard color as selected by Architect.
 - H. Damper: Knob-operated internal damper.
 - I. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by 7 inches, integral with enclosure.
 - J. Enclosure Style: Flat top.
 1. Top Outlet Grille: Punched louver; painted to match enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive convection heating units for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for hydronic-piping connections to verify actual locations before convection heating unit installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FINNED-TUBE RADIATOR INSTALLATION

- A. Install units level and plumb.
- B. Install enclosure continuously around corners, using outside and inside corner fittings.
- C. Join sections with splice plates and filler pieces to provide continuous enclosure.

- D. Install access doors for access to valves.
- E. Install enclosure continuously from wall to wall.
- F. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
- G. Install valves within reach of access door provided in enclosure.

3.3 CONVECTOR INSTALLATION

- A. Install units level and plumb.
- B. Install valves within reach of access door provided in enclosure.
- C. Install air-seal gasketing between wall and recessing flanges or front cover of fully recessed unit.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water units and components to piping according to Division 23 Section "Hydronic Piping."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Connect steam units and components to piping according to Division 23 Section "Steam and Condensate Heating Piping."
 - 1. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
- D. Install control valves as required by Division 23 Section "Instrumentation and Control for HVAC."
- E. Install piping adjacent to convection heating units to allow service and maintenance.

3.5 FIELD QUALITY CONTROL

- A. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

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END OF SECTION 23 8233

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SECTION 23 8239 - UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Cabinet unit heaters with centrifugal fans and hot-water coils.
 - 2. Propeller unit heaters with hot-water coils.

1.2 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Location and size of each field connection.
 - 2. Details of anchorages and attachments to structure and to supported equipment.
 - 3. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cabinet Unit Heater Filters: Furnish one spare filter for each filter installed.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Corporation.
 2. Johnson Controls.
 3. Daikin/McQuay.
 4. Modine.
 5. Rittling.
 6. Sigma.
 7. Sterling.
 8. Trane.
 9. Vulcan.
- B. Description: A factory-assembled and -tested unit complying with ARI 440.
- C. Coil Section Insulation: Surfaces exposed to airstream shall be coated to prevent erosion of insulation.
1. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
- D. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect. Include removable panels with tamperproof fasteners and the following:
1. Steel recessing flanges with finish to match cabinet.
 2. Key operated control access door.
 3. Safety chains on horizontal units.
- E. Filters: Pleated, 90 percent arrestance and 7 MERV.
- F. Fan and Motor Board: Removable.
1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
 2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 3. Motor Starter: Toggle switch with thermal overload and off position.
- G. Electrical Connection: Factory wire unit for a single field connection with disconnect switch.
- H. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.
- I. Basic Unit Controls:

1. Provide unit "DDC controls ready" for field furnished and installed controls by controls Installer.
 2. Unit-mounted with the following features:
 - a. Control voltage transformer.
 - b. Fan on-auto switch.
 - c. Manual fan speed switch.
- J. Unit Operations:
1. Energize fan and open control valve to provide heating if temperature falls below thermostat set point.
 2. Energize fan and electric-resistance coil to provide heating if temperature falls below thermostat set point.
- K. Basic Unit Controls: Unit-mounted with the following features.
1. Control voltage transformer.
 2. Return air thermostat for wall mounted heaters and wall mounted for ceiling mounted heaters provided by temperature controls installer.
 3. Heat-off switch.
 4. Fan on-auto switch.
 5. Manual fan speed switch.
- L. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

2.2 HOT WATER PROPELLER UNIT HEATERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carrier Corporation.
 2. Dunham-Bush, Inc.
 3. Daikin/McQuay.
 4. Modine
 5. Rittling, a div. of Hydro-Air Components.
 6. Sigma.
 7. Sterling.
 8. Trane.
 9. Vulcan.
- B. Description: An assembly including casing, coil, fan, and motor in vertical and horizontal discharge configuration with adjustable discharge louvers.
- C. Cabinet: Removable panels for maintenance access to controls.
- D. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.
- E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- F. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

- G. Electrical Connection: Factory wire unit for a single field connection.
 - 1. Include control voltage transformer for wall mounted thermostat.
- H. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.
- I. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F, with manual air vent.
- J. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- K. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Type: Permanently lubricated.
- L. Control Devices:
 - 1. Wall-mounting 24V thermostat.
- M. Control devices and operational sequences are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."

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.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install cabinet unit heaters to comply with NFPA 90A.
- B. Install propeller unit heaters level and plumb.
- C. Suspend cabinet unit heaters from structure with elastomeric hangers.
- D. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers.
- E. Install new filters in each cabinet heater within two weeks of Substantial Completion.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Comply with safety requirements in UL 1995.
- D. Unless otherwise indicated, install union and ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping."
- E. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, test coils and connections for leaks.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

- A. Adjust initial temperature set points.

END OF SECTION 23 8239

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SECTION 23 8316 – RADIANT HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes radiant heating piping, including pipes, fittings, and piping specialties.
- B. Related Requirements:
 - 1. Section 07 2100 "Thermal Insulation" for insulation installed under concrete with radiant heat.

1.2 DEFINITIONS

- A. PEX: Crosslinked polyethylene.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of radiant heating pipe, fitting, manifold, specialty, and control.
 - 1. For radiant heating piping and manifolds, include pressure and temperature rating, oxygen-barrier performance, fire-performance characteristics, and water flow and pressure drop characteristics.
- B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
 - 1. Shop Drawing Scale: 1/8 inch = 1 foot.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 COORDINATION

- A. Coordinate thickening of slabs where required for adequate encasement of radiant heating piping components.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

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

2. Mr. PEX
 3. Viega LLC.
 4. Uponor.
 5. Watts Radiant, Inc.; a division of Watts Water Technologies, Inc.
 6. Zurn Plumbing Products Group.
- B. Pipe Material: Crosslinked polyethylene (PEX), manufactured in accordance with ASTM F876 and ASTM F877.
- C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F according to DIN 4726.
- D. Fittings: ASTM F1960 metal cold expansion or ASTM F 1807, metal insert and crimp rings.
- E. Pressure/Temperature Rating: Minimum 100 psig and 140 deg F.

2.2 DISTRIBUTION MANIFOLDS

- A. Manifold: Minimum NPS 1, brass, copper, stainless steel, or modular plastic.
- B. Manual Air Vents:
1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Key furnished with valve, or screwdriver bit.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/8.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 225 deg F.
- C. Balancing Valves:
1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
 2. Ball or Plug: Brass or stainless steel.
 3. Globe Cartridge and Washer: Brass with EPDM composition washer.
 4. Seat: PTFE.
 5. Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 6. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
 7. CWP Rating: Minimum 125 psig.
 8. Maximum Operating Temperature: 250 deg F.
- D. Mounting Brackets: Copper, or plastic or copper-clad steel, where in contact with manifold.
- E. Manifold Wall Cabinets: Painted steel or plastic recessed cabinet with removable or hinged door.

2.3 PIPING SPECIALTIES

- A. Cable Ties:

1. Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch.
3. Tensile Strength: 20 lb, minimum.
4. Temperature Range: Minus 40 to plus 185 deg F.

B. Floor-Mounting Clamps:

1. Two bolt, steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch.
3. Width: Minimum, wider than tubing.

2.4 CONTROLS

- A. Temperature-control devices and sequence of operations are specified in Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operations for HVAC Controls."
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Danfoss Inc.
 2. HeatLink USA Inc.
 3. Honeywell.
 4. Infloor Radiant Heating Inc.
 5. IPEX Inc.
 6. REHAU.
 7. Slant/Fin Corp.
 8. Stadler-Viega.
 9. tekmar Control Systems, Ltd.
 10. Uponor Wirsbo Co.
 11. Vanguard Piping Systems, Inc.
 12. Watts Radiant, Inc.; a division of Watts Water Technologies, Inc.
 13. Zurn Plumbing Products Group.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and substrates to receive radiant heating piping for compliance with requirements for installation tolerances and other conditions affecting performance.
1. Ensure that surfaces and pipes in contact with radiant heating piping are free of burrs and sharp protrusions.
 2. Ensure that surfaces and substrates are level and plumb.
 3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Install the following types of radiant heating piping for the applications described:

1. Piping in Interior Concrete Floors: PEX.

3.3 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop or Coordination Drawings.
- B. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
- C. Connect radiant piping to manifold in a reverse-return arrangement.
- D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
- E. Install slab sensors where indicated with tops level with concrete.
- F. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Division 08 Section "Access Doors and Frames."
- G. Refer to Division 23 Section "Hydronic Piping" for pipes and connections to hydronic systems.
- H. Refer to Division 23 Section "HVAC Water Treatment" for glycol-solution fill requirements.
- I. Piping in Interior Concrete Floors:
 1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 2. Space cable ties a maximum of 18 inches o.c., and at center of turns or bends.
 3. Maintain 2-inch minimum cover.
 4. Install a sleeve of 3/8-inch- thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 5. Maintain minimum 40-psig pressure in piping during concrete placement and continue for 24 hours after placement.
- J. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.
- K. After system balancing has been completed, mark balancing valves to permanently indicate final position.
- L. Perform the following adjustments before operating the system:
 1. Open valves to fully open position.
 2. Check operation of automatic valves.
 3. Set temperature controls so all zones call for full flow.
 4. Purge air from piping.
- M. After the concrete heating panel has cured as recommended by supplier, operate radiant heating system as follows:

1. Start system heating at a maximum of 10 deg F above the ambient radiant panel temperature, and increase 10 deg F each following day until design temperature is achieved.
2. For freeze protection, operate at a maximum of 60 deg F supply-water temperature.

3.4 FIELD QUALITY CONTROL

A. Prepare radiant heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.
3. Flush with clean water, and clean strainers.

B. Tests and Inspections:

1. Leak Test: After installation and before encasement, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning radiant heating piping components that do not pass tests, and retest as specified above.

D. Prepare a written report of testing.

END OF SECTION 23 8316

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SECTION 26 0500 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical Scope of work
 - 2. Electrical equipment coordination and installation.
 - 3. Rough-in
 - 4. Electrical Demolition
 - 5. Common electrical installation requirements.

1.3 SCOPE OF WORK

- A. The scope of work is to include but not be limited to the following:
 - 1. Obtain all required electrical construction permits and inspections.
 - 2. File electrical service request with the Electric Utility for a new (upgraded, primary, secondary) electrical service.
 - 3. Provide cash allowance in bid for utility installation charges.
 - 4. Provide concrete pad and conduit for service transformer installation.
 - 5. Provide a 277/480 volt, 3 phase, 4 wire, distribution system for lighting and HVAC equipment.
 - 6. Provide a 120/208 volt, 3 phase, 4 wire, distribution system for convenience receptacles, small appliances and small motors.
 - 7. Refer to mechanical drawings, security, communications and access control drawings. Provide low voltage raceways (1/2" minimum) for all thermostats, controls and low voltage systems. No low voltage wiring of any type shall be visible in exposed ceiling areas.
 - 8. Provide complete electrical installation including all components, i.e. light fixtures, lamps, receptacles, conduit, wire, etc.
 - 9. Provide fire alarm system.
 - 10. Provide raceway system for sound system, clock/program system, and security system.
 - 11. Provide raceway system for telephone/data networking systems.
 - 12. Provide for Owner training by factory representatives in operation and maintenance of systems where specified.
 - 13. Provide selective demolition of electrical systems and equipment as indicated on the drawings.
 - 14. Submit documentation such as shop drawings, record documents, maintenance manuals, infrared scan results, systems test results, fire alarm system certification, etc. as specified.

1.4 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate electrical systems, equipment and materials installation with other building components.
- C. Coordinate installation of electrical panelboard tubs, backboxes and concealed conduit and tubing with masonry/concrete work.
- D. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies and controlling agencies. Provide required connection for each service.
- E. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- F. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- G. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.5 INTERPRETATIONS

- A. It is the intent of these Drawings and Specifications to result in a complete electrical installation in complete accordance with applicable code and ordinances.
- B. Drawings are diagrammatic in character and do not necessarily indicate every required junction box, pull box, ell, etc. Items not specifically mentioned in the specification or noted on the Drawings, but which are necessary to make a complete working installation, shall be included.
- C. Drawings and Specifications are complementary. Whatever is called for in either is binding as though called for in both. The more stringent requirement shall govern.

PART 2 - PRODUCTS

PART 3 - EXECUTION

3.1 ROUGH-IN

- A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
- B. Refer to equipment specifications in Divisions 02 through 49 for rough-in requirements.

3.2 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1, Standard Practices for Good Workmanship in Electrical Construction.
- B. Arrange for chases, slots and openings in other building components during progress of construction, to allow for electrical installations.
- C. Sequence, coordinate and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
- D. Install systems, materials and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
- E. Measure indicated mounting heights to bottom of unit for suspended items and to bottom of unit for wall-mounting items or as indicated on drawings.
- F. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- G. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- H. Right of Way: Give to piping systems installed at a required slope.

3.3 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 26 0500

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SECTION 26 0513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes cables, splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of cable, splice and termination.
- B. Qualification Data: For testing agency.
- C. Source quality-control test reports.
- D. Material Certificates: For each cable and accessory type, signed by manufacturers, certifying that cables comply with requirements specified in Part 2 Article "Source Quality Control."
- E. Field quality-control test reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with IEEE C2 and NFPA 70.
- C. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.
- D. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the InterNational Electrical Testing Association (NETA) and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise testing specified in Part 3.
- E. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

1.5 CLOSEOUT SUBMITTALS

- A. Dated documentation of torque values of cable connections on all equipment.

1.6 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect at least two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cables:
 - a. American Insulated Wire Corp.; a Leviton Company.
 - b. BICC Brand-Rex Company.
 - c. General Cable Corporation.
 - d. Kerite Co. (The); Hubbell Incorporated.
 - e. Okonite Company (The).
 - f. Pirelli Cables & Systems NA.
 - g. Rome Cable Corporation.
 - h. Southwire Company.
 - 2. Cable Splicing and Terminating Products and Accessories:
 - a. Engineered Products Co.
 - b. G&W Electric Co.
 - c. MPHusky.
 - d. Raychem Corp.; Telephone Energy and Industrial Division.
 - e. RTE Components; Cooper Power Systems, Inc.
 - f. Scott Fetzer Co. (The); Adalet, Inc.
 - g. Thomas & Betts Corporation.
 - h. Thomas & Betts/Elastimold.
 - i. 3M Company; Electrical Products Division.

2.2 CABLES

- A. Cable Type: MV105, with copper conductor and concentric lay, class B stranding.
- B. Comply with UL-1072, AEIC CS8, ICEA S-93-639, and ICEA S-97-682.

- C. Conductor Insulation: Ethylene-propylene rubber.
 - 1. Voltage Rating: 15 kV.
 - 2. Insulation Thickness: 133 percent insulation level.
- D. Shielding and Jacket: Concentric neutral corrugated copper drain wires embedded in an extruded, semi-conducting, chlorinated, polyethylene jacket.
- E. Cable Jacket: Sunlight-resistant PVC.

2.3 SPLICE KITS

- A. Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
 - 1. Combination tape and cold-shrink-rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
 - 2. Heat-shrink splicing kit, polymeric construction with outer heat-shrink jacket.
 - 3. Premolded, cold-shrink-rubber, in-line splicing kit.
 - 4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

- A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
 - 1. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with external plastic jacket.
 - 2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
 - 3. Heat-shrink sheath seal kit with phase- and ground-conductor re-jacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
 - 4. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.
- B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
 - 1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
 - 2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
 - 3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
 - 4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.

- 5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
- 6. Class 3 Terminations: Kit with stress cone and compression-type connector.
- C. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

- A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
- B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
- C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
- E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
 - 1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
 - 2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
 - 3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
 - 4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

2.6 ARC-PROOFING MATERIALS

- A. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
- B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.
- C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

2.7 SOURCE QUALITY CONTROL

- A. Test and inspect cables according to ICEA S-97-682 before shipping.
- B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cables according to IEEE 576.
- B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
 - 1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
 - 2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.
- C. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
- D. Support cables according to Division 26 Section "Common Work Results for Electrical."
- E. Install direct-buried cables on leveled and tamped bed of 3-inch- thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4 inches of tamped earth.
 - 1. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
 - 2. Install "buried-cable" warning tape 12 inches above cables.
- F. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.
- G. Install cable splices at pull points and elsewhere as indicated; use standard kits.
- H. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
- I. Install separable insulated-connector components as follows:
 - 1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
 - 2. Portable Feed-Through Accessory: Three.
 - 3. Standoff Insulator: Three.
- J. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping."
- K. Install fault indicators on each phase where indicated.

- L. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
- M. Identify cables according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

- A. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
 - 2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
- C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 0513

SECTION 26 0519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.2 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports.

1.3 CLOSEOUT SUBMITTALS

- A. Dated documentation of torque values of cable connections on all equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Conductor Material: Copper complying with NEMA WC 70/ICEA S-95-658 (unless 100A & larger circuits, then use Aluminum)
- B. Conductor Insulation Types: Type THHN-2, THWN-2, Type XHHW-2, Type RHW2 and Type SO

2.2 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 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 NFPA 70.

2.4 **ALUMINUM CONDUCTORS (100A & LARGER CIRCUITS)**

- A. *Provide an alternate price to use aluminum alloy conductors for the incoming service feeders and distribution feeders sizes #3 AWG to 1000 Kcmil. Price shall include the aluminum conductors and the cost to increase the conduit size as required to satisfy the NEC.*
- B. Description:
1. *Aluminum alloy conductors shall be compact stranded conductors of a recognized Aluminum Association 8000 Series aluminum alloy conductor material (AA-8000 series alloy).*
 2. *AA-8000 series alloy conductor must be Alcan Cable Stabiloy® or approved equal.*
 3. *Compliance with the elongation requirement per Table 10.1 of UL Standard 1581 for stranded AA-8000 series aluminum alloy conductors shall be determined on wires taken from the conductor after stranding by manufacturer.*
- C. *Insulation :*
1. *For use in raceways: Type XHHW-2, temperature rating 90° C.*
- D. *Connections for Conductors :*
1. *Using Mechanical Compression Type Connectors:*
 - a. *Connectors shall be dual rated (AL7CU or AL9CU) and Listed by UL for use with aluminum and copper conductors and sized to accept aluminum conductors of the ampacity specified.*
 - b. *The lugs shall be marked with wire size, die index, number and location of crimps and shall be suitably color-coded. Lug barrel shall be factory prefilled with a joint compound Listed by UL.*
 - c. *Using a suitable stripping tool, to avoid damage to the conductor, remove insulation from the required length of the conductor.*
 - d. *Wire brush the conductor.*
 - e. *Crimp the connection per the connector manufacturer's recommendation.*
 - f. *Wipe off any excess joint compound.*
- E. *Termination of Aluminum Conductor to Aluminum Bus:*
1. *Prepare a mechanical compression connection.*
 2. *Hardware:*
 - a. *Bolts: Anodized alloy 2024-T4 and conforming to ANSI B18.2.1 and to ASTM B211 or B221 chemical and mechanical property limits.*
 - b. *Nuts: Aluminum alloy 6061-T6 or 6262-T9 and conforming to ANSI B18.2.2.*
 - c. *Washers: Flat aluminum alloy 2024-T4, Type A plain, standard wide series conforming to ANSI B27.2.*
 - d. *Lubricate and tighten the hardware as per the manufacturer's recommendations.*
- F. *Termination of Aluminum Conductor to Copper Bus:*
1. *Prepare a mechanical compression connection.*
 2. *Hardware:*
 - a. *Bolts: Plated or galvanized medium carbon steel; heat treated, quenched and tempered equal to ASTM A-325 or SAE grade 5.*

- b. Nuts: Heavy semi-finished hexagon, conforming to ANSI B18.2.2, threads to be unified coarse series (UNC), class 2B.
- c. Washers: Should be steel, Type A plain standard wide series conforming to ANSI B27.2.
- d. Belleville conical spring washers: Shall be of hardened steel, cadmium plated or silicone bronze.
- e. Lubricate and tighten the hardware as per the manufacturer's recommendations.

G. *Conduit Adjustment:*

- 1. *It is the contractor's responsibility to adjust the conduit size in accordance with the NEC.*

PART 3 - EXECUTION

3.1 CONDUCTOR AND INSULATION APPLICATIONS

- A. Minimum conductor size for power wiring #12 AWG.
- B. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.
- C. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- D. Feeders Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- E. Feeders Concealed in Concrete, below Slabs-on-Grade, and in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- F. Fire Pump Feeder: Provide UL 2196 listed electrical circuit protective system with a minimum 2-hour fire rating such as RHW2 or Draka "Lifeline MC". Alternatively to RHW2, feeder can be routed underground into 2-hour rated room or routed in 2 hour rated soffit.
- G. Emergency Power Feeder: Provide UL 2196 listed electrical circuit protective system with a minimum 2-hour fire rating such as RHW2 or Draka "Lifeline MC". This includes all legally required, life safety ATS's, panels, branch panels. Routing the feeder in a non-sprinkled ceiling space of a sprinkled building does not negate the need for this requirement. Alternatively to RHW2, feeder can be routed underground into 2-hour rated room or routed in 2 hour rated soffit.
- H. Emergency Power Branch Circuits: Other than NFPA 130 applications, provide 2-hour rated cables as indicated above.
- I. Exposed Branch Circuits, including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- J. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway.
- K. Fixture Whips: Type MC cable may be used for light fixture whips only, with a maximum length of 6 feet.
- L. Branch Circuits Concealed in Concrete and below Slabs-on-Grade: Type THHN-2-THWN-2, single conductors in raceway.

- M. Underground Feeders and Branch Circuits: Type THHN-2-THWN-2, single conductors in raceway.
- N. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- O. Fire Alarm Circuits: UL2196 rated cabling in raceway or Power-limited, fire-protective, signaling circuit cable where raceway is not specified.
- P. Class 1 Control Circuits: Type THHN-2-THWN-2, in raceway.
- Q. Class 2 Control Circuits: Type THHN-2-THWN-2, in raceway or Power-limited cable, concealed in building finishes where raceway is not specified.
- R. Dimming Control Circuits: Provide 600V rated cabling for 0-10V dimming circuits. Wiring to be installed in conduit where exposed. Install in accordance with the proper class 1 or class 2 circuit requirements as required by the lighting control system used.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

- A. Where 120 volt, 20 amp, branch circuit wiring from panelboard to first outlet exceeds 100 feet in length, increase home-run wire size to #10 AWG.
- B. Where 277 volt, 20 amp, branch circuit wiring from panelboard to first light fixture exceeds 150 feet in length, increase home-run wire size to #10 AWG.
- C. Common neutral conductors **shall not** be used for convenience outlet or lighting branch circuits.
- D. Neutral conductors shall be clearly labeled at the panelboard with the circuit number of associated phase conductors.
- E. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- F. 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.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- I. Support cables according to Division 26 Section "Common Work Results for Electrical."
- J. Seal around cables penetrating fire-rated elements according to Division 07 Section "Penetration Firestopping."
- K. Cable tie tightness where applicable shall be per NECA and UL standards, do not over tighten.
- L. One-hour and Two-hour cables should be installed using components specified in appropriate FHIT document and Manufacturer Installation guide. Substitutions are not permitted.

3.3 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 0553 "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.

3.4 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 and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches of slack.

3.5 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 Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.
 - 2. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- C. Remove and replace malfunctioning units and retest as specified above.

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END OF SECTION 26 0519

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

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. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with IEEE837 – Standard for qualifying permanent connections used in Substation Grounding

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grounding Conductors, Cables, Connectors, and Rods:
 - a. Copperweld Corp.
 - b. Erico Inc.; Electrical Products Corporation.
 - c. FCI Burndy Products.
 - d. Ideal Industries, Inc.
 - e. ILSCO.
 - f. Kearney/Cooper Power Systems.
 - g. O-Z/Gedney Co.; a business of the EGS Electrical Group.
 - h. Raco, Inc.; Division of Hubbell.
 - i. Thomas & Betts, A Member of the ABB Group.

2.2 GROUNDING CONDUCTORS

- A. For insulated conductors, comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Material: Copper.
- C. Equipment Grounding Conductors: Insulated with green-colored insulation.
- D. Grounding Electrode Conductors: Stranded cable.
- E. Underground Conductors: Bare stranded unless otherwise indicated.
- F. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- G. Grounding Bus: Bare, annealed copper bars of rectangular cross section, with insulators.

2.3 CONNECTOR PRODUCTS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Compression Connectors: Irreversible hydraulic compression kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- E. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long barrel, two-bolt connection to ground bus bar

2.4 GROUNDING ELECTRODES

- A. Ground Rods: Sectional type; copper-clad steel.

1. Size: $\frac{3}{4}$ inch in diameter by 120 inches long.
- B. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.
- B. In raceways, use insulated equipment grounding conductors.
- C. Exothermic-Welded or Irreversible Compression Connections: Use for connections to structural steel and for underground connections.
- D. Equipment Grounding Conductor Terminations: Use bolted pressure clamps.
- E. Install equipment grounding conductors or grounding electrode conductors that are routed through exposed ceiling spaces in conduit.
- F. Label equipment grounding conductors and grounding electrode conductors as indicated in "Identification for Electrical Systems".
- G. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- H. Ground Rod Clamps at Test Wells: Use bolted pressure clamps with at least two bolts.
- I. Grounding Bus: Install in electrical service equipment rooms.
 1. Size: $\frac{1}{4}$ inch by 2 inches bare, annealed copper.
 2. Use insulated spacer; space 1 inch from wall and support from wall 6 inches above finished floor, unless otherwise indicated.
 3. At doors, route the bus up to the top of the door frame, across the top of the doorway, and down to the specified height above the floor.
- J. Underground Grounding Conductors: Use tinned-copper conductor, No. 2/0 AWG minimum unless noted otherwise. Bury at least 24 inches below grade.

3.2 EQUIPMENT GROUNDING CONDUCTORS

- A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.

3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. Armored and metal-clad cable runs.
 8. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 9. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
 10. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- D. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- E. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.3 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 Rods: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes.
1. Drive ground rods until tops are 6 inches below finished floor or final grade, unless otherwise indicated.
 2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except as otherwise indicated. Make connections without exposing steel or damaging copper coating.
 3. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

- 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 so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
 - 4. Bond all steel structure and concrete reinforcement steel / rebar.
- 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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 - 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Concrete-Encased Electrodes: Connect grounding conductor to the foundation reinforcing bars or rods and bond the bars together with steel tie wires.
- F. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- G. Grounding Variable-Frequency Motors: Provide copper braided grounding strap between motor and metallic conduit (EMT or IMC) in addition of the equipment grounding conductor on motors controlled with a variable-frequency controller.

3.4 CONNECTIONS

- A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
 - 1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
 - 2. Make connections with clean, bare metal at points of contact.
 - 3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
- B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

- C. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.
- D. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.
- E. Tighten screws and bolts for grounding and bonding 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.
- F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.
- G. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.5 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Duct Banks: Install a grounding conductor with at least 50 percent ampacity of the largest phase conductor in the duct bank.
- B. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.6 UNDERGROUND DISTRIBUTION SYSTEM GROUNDING

- A. Duct Banks: Install a grounding conductor with at least 50 percent ampacity of the largest phase conductor in the duct bank.
- B. Manholes and Handholes: Install a driven ground rod close to wall and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide a No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Connections to Manhole Components: Connect exposed-metal parts, such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and counterpoise circling pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Use tinned-copper conductor not less than No. 2 AWG for counterpoise and for taps to equipment ground pad. Bury counterpoise not less than 18 inches below grade and 6 inches from the foundation.

3.7 LABELING

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Make tests at ground rods before any conductors are connected.
- B. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.

2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
 5. Manhole Ground: 10 ohms.
- C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.2 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.3 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation/ A Member of the ABB Group.

- f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 5. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.

- 6. Toggle Bolts: All-steel springhead type.
- 7. Hanger Rods: Threaded steel.

- G. ***Correctional Projects: Provide irreversible fasteners with security / tamper proof heads. All conduit straps shall be two hole. Provide fasteners in all available connection points to prevent prying or leverage for removal of covers or equipment.***

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 for application of hangers and supports for electrical equipment and systems, except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where Table 1 lists maximum spacings less than stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to trapeze member with clamps approved for application.
 - 2. Secure raceways and cables to these supports with single-bolt conduit clamps using spring friction action for retention in support channel.
- D. 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.
- E. Provide independent support rings/shepherd hooks for any low voltage communications systems cabling. Cabling shall not rest on ceiling and shall be organized neatly on hooks. Cable shall not be visible in exposed ceiling spaces.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 for installation requirements, except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.

- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. 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, beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or spring-tension clamps.
 - 7. To Light Steel: Sheet metal screws.
 - 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.
- D. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and seismic criteria at Project.
- B. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- C. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 03 3000 "Cast-in-Place Concrete."
- D. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
 - 1.

END OF SECTION 26 0529

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SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal conduits, tubing, and fittings.
2. Nonmetal conduits, tubing, and fittings.
3. Metal wireways and auxiliary gutters.
4. Nonmetal wireways and auxiliary gutters.
5. Surface raceways.
6. Boxes, enclosures, and cabinets.
7. Handholes and boxes for exterior underground cabling.

1.2 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.

1.3 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. LEED Submittals:
1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, hand holes and attachment details.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Conduit 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 conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

1.5 COORDINATION

- A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets, and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

- A. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. GRC: Comply with ANSI C80.1 and UL 6.
- C. EMT: Comply with ANSI C80.3 and UL 797.
- D. FMC: Comply with UL 1; zinc-coated steel.
- E. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- F. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew or compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- G. Joint Compound for GRC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Listing and Labeling: Nonmetallic conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ENT: Comply with NEMA TC 13 and UL 1653.
- C. RNC: Type EPC-40-PVC and EPC-80-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. LFNC: Comply with UL 1660.
- E. Fittings for ENT and RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.

- F. Fittings for LFNC: Comply with UL 514B.
- G. Solvent cements and adhesive primers shall have a VOC content of 510 and 550 g/L or less, respectively, when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- H. Solvent cements and adhesive primers shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.3 PVC COATED RIGID METAL CONDUIT

- A. The PVC coated rigid metal conduit shall be hot dip galvanized inside and out. The interior galvanizing shall be listed per UL 6. The exterior galvanizing shall be listed per UL 6 as primary corrosion protection. Thread protectors shall be used on the exposed threads of the PVC coated conduit. PVC coated RMC steel conduit shall comply with UL 6, ANSI C80.1, and NEMA RN-1 standards without exception.
- B. The PVC coating, in compliance with NEMA RN-1, shall be nominal 40 mils in thickness continuous over the entire length of the conduit except at the threads, and be free of blisters, bubbles or pin- holes. PVC shall be UL listed as a primary corrosion protection.
- C. A urethane coating shall be uniformly and consistently applied to the interior of conduit. This internal coating shall be a nominal 2 mils thickness. All male threads on elbows and nipples shall be zinc coated using zinc rich paint.
- D. Coated couplings shall be used with coated conduit. The thickness of the coating on couplings shall be at least equal to the thickness of the coating on the conduit. Each coated coupling shall have a flexible PVC sleeve which extends from each end of the coupling and which will overlap the PVC coating on the conduit when the coupling has been installed on the conduit. The length of the sleeve extension(s) shall be at least equivalent to the nominal Trade Size for sizes 1/2" up through 1-1/2". For Trade Size 2" through 6", the length of the sleeve extension(s) shall be at least 2 inches. The PVC sleeve shall be a nominal thickness of 40 mils in thickness. The inside diameter of the overlapping sleeve shall be less than the outside diameter of the PVC-coated conduit.

2.4 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Material and Construction: Sheet metal sized and shaped as indicated, NEMA 1 or 3R as required.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.
- D. Wireway Covers: Hinged type, Screw-cover type, Flanged-and-gasketed type.
- E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS AND AUXILIARY GUTTERS

- A. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
- B. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- C. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

2.6 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers. Finish with manufacturer's standard prime coating and ivory finish coat.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Thomas & Betts Corporation / A Member of the ABB Group.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
- C. Surface Metal Raceways: Satin anodized extruded aluminum with snap-on covers.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Post Glover
 - b. Thomas & Betts Corporation / A Member of the ABB Group
 - c. Wiremold Company
- D. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC compound with matte texture ivory color.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hellermann Tyton
 - b. Hubbell, Inc.; Wiring Device Division.
 - c. Lamson & Sessions; Carlon Electrical Products.
 - d. Mono-systems, Inc.
 - e. Panduit Corp.
 - f. Walker Systems, Inc.; Wiremold Company (The).
 - g. Wiremold Company (The); Electrical Sales Division.
- E. Types, sizes, and channels as indicated and required for each application, with fittings that match and mate with raceways. Provide concealed support clips or fasten raceway internally. Do not use external mounting straps.

2.7 BOXES, ENCLOSURES, AND CABINETS

- A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- E. Metal Floor Boxes:
 - 1. Material: Sheet-metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Nonmetallic Floor Boxes: Nonadjustable, round.
 - 1. Listing and Labeling: Nonmetallic floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- H. Paddle Fan Outlet Boxes: Nonadjustable, designed for attachment of paddle fan weighing 70 lb.
 - 1. Listing and Labeling: Paddle fan outlet boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- I. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- J. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- K. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous hinge cover and flush latch.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.
- L. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and concealed hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.
- M. Telephone/Data Backboxes: Provide 2-gang, 3 ½ inch deep backboxes with single gang raised cover unless noted otherwise on plans.

- N. Low Voltage Boxes: 5-Square telecommunications outlet boxes (5 in. square x 2.875 deep w/ cable management) shall be used for all low voltage applications. 5-square box shall support 5e, 6, augmented 6, 7, and optical fiber cables. Low voltage boxes shall support integral cable management by allowing slack cable to be wound internally while maintaining minimum bend radius requirements. 5-square boxes shall also be used for all fire alarm applications.

O.

2.8 FACTORY FINISHES

- A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard gray paint applied to factory-assembled surface raceways, enclosures, and cabinets before shipping.

2.9 CABLE PATHWAY AND FIRESTOP DEVICE

- A. Manufacturer:
1. Specified Technologies, Inc., EZ-Path fire rated pathway.
 2. Wiremold, FlameStopper FS Series thru-wall fitting for fire walls.
- B. Description: Through-the-wall 3" x 3" steel wiring channel or 4" EMT equipped with heat expanding intumescent fire stopping material.
- C. Wiring channel shall be provided with steel wall plates allowing for single or multiple channels to be ganged together.
- D. Wiring channel shall have an F rating equal to the rating of the barrier in which it is installed.
- E. Wiring channel shall be capable of allowing a 0 to 100 percent visual fill of cable.
- F. Wiring channel shall be tested in accordance with ASTM E 814 (ANSI/UL1479). Channel shall bear the UL classification marking.
- G. Provide the quantity of devices needed to allow a cable pass cross section capacity of 50 percent of the adjacent cable tray cross section.

2.10 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
1. Standard: Comply with SCTE 77.

2. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC".
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Wall Style: Flared wall assembly.

C.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors:

1. Exposed: Rigid steel. (No RNC Allowed)
2. Concealed, Aboveground: Rigid steel.
3. Underground: RNC Schedule 80.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
5. Boxes and Enclosures: NEMA 250, Type 3R or 4.

B. Indoors:

1. Exposed in Unfinished Utility Spaces (mechanical rooms, electrical rooms and tunnels): EMT.
2. Exposed in Finished Spaces: All conduit shall be concealed unless specifically indicated on plans.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit.
4. Concrete Floors: RNC.
5. Concealed in Ceilings and Interior Walls and Partitions: EMT
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC; except use LFMC in damp or wet locations.
7. Damp or Wet Locations: Rigid steel conduit.
8. Boxes and Enclosures: NEMA 250, Type 1, except as follows:
 - a. Damp or Wet Locations: NEMA 250, Type 4, nonmetallic.

C. Minimum Raceway Size: 1/2-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this Article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

- B. Provide separate raceways for lighting, receptacle, and motor loads. Do not mix branch circuit wiring for these different loads in the same raceway.
- C. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- D. Complete raceway installation before starting conductor installation.
- E. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Support raceways as specified in Division 26 Section "Common Work Results for Electrical."
- G. Install temporary closures to prevent foreign matter from entering raceways.
- H. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portions of bends are not visible above finished slab.
- I. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- J. Make bends and offsets so ID is not reduced. Keep legs of bends in same plane and keep straight legs of offsets parallel, unless otherwise indicated.
- K. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
 - 1. Install concealed raceways with a minimum of bends in shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.
 - 2. Conduit and EMT may be surface mounted in Mechanical and Electrical Rooms except for wiring devices, light switches, low voltage devices or any other device shall be concealed in new wall.
 - 3. Surface mounted conduit or EMT may be used where specifically approved by Architect/Engineer. In such situations, the conduit, fastening devices, and junction boxes shall be painted to match the adjacent surface.
- L. Raceways Embedded in Slabs: Install in middle 1/3 of slab thickness where practical and leave at least 2 inches of concrete cover.
 - 1. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.
 - 2. Space raceways laterally to prevent voids in concrete.
 - 3. Run conduit larger than 1-inch trade size parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 4. Change from nonmetallic tubing to rigid steel conduit before rising above floor or grade.
- M. Install exposed raceways parallel or at right angles to nearby surfaces or structural members and follow surface contours as much as possible.
 - 1. Run parallel or banked raceways together on common supports.
 - 2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.
- N. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- O. Join raceways with fittings designed and approved for that purpose and make joints tight.
 1. Use insulating bushings to protect conductors.
- P. Tighten set screws of threadless fittings with suitable tools.
- Q. Terminations:
 1. Where raceways are terminated with locknuts and bushings, align raceways to enter squarely and install locknuts with dished part against box. Use two locknuts, one inside and one outside box.
 2. Where raceways are terminated with threaded hubs, screw raceways or fittings tightly into hub so end bears against wire protection shoulder. Where chase nipples are used, align raceways so coupling is square to box; tighten chase nipple so no threads are exposed.
 3. Telephone, data and fiber optic cable conduits shall be provided with bushings on conduit ends.
- R. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- S. Color-Coding: Paint fire alarm system junction boxes and covers red.
- T. Raceways for Optical Fiber and Communications Cable: Install as follows:
 1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
 2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
 3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- U. Telephone, data, AV, security, access control, fiber optic cable system, building control cabling, lighting control, 0-10V dimming control and any other low voltage systems cabling shall be installed in conduit in areas of exposed ceiling. In areas with accessible ceilings, the low voltage systems cables shall be neatly routed and independently supported with cable rings to the nearest cable tray, technology closet, conduit run or equipment connection. Systems to be in conduit in accessible ceiling spaces where required elsewhere in the specification or drawings.
- V. Telephone, data and fiber optic cable system conduit shall be provided with wide sweep bends.
- W. Telephone, data and fiber optic cable outlets shall be provided with a 1 inch conduit stubbed into accessible ceiling space unless noted otherwise on the drawings. Provide bushings on the ends of the conduit.
- X. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70.

Y. 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 conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - 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.

Z. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

AA. Flexible Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in damp or wet locations. Install separate ground conductor across flexible connections.

BB. Flexible Connections to Lighting Fixtures:

1. Above ceilings that are continuous to wall: Provide flexible conduit to all recessed lighting fixtures, maximum length as indicated. For fixtures mounted on grid ceilings, provide adequate length of flexible conduit to allow relocation of fixture on grid space in any lateral direction.
2. Above clouds or above suspended ceiling elements that are visible and exposed, Flexible Connections to Lighting Fixtures shall be limited to reduce sight of flexible conduit. Flexible connections to light fixtures shall not be visible from standing on the floor or nearby landings or overlooks. Minimize angle of visibility, run EMT as necessary and coordinate with trades to group systems to minimize drops. All drops to element/cloud to be EMT and shall not be flex.

CC. Equipment Grounding Conductor: Install a green equipment grounding conductor in all flexible conduit and non-metallic (PVC) conduit.

DD. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.

EE. Recessed back-to-back boxes are not permitted in the same wall. Arrange boxes with at least 12 inches of horizontal spacing.

- FF. Recessed Boxes in Masonry Walls: Saw-cut opening for box in masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between the box and cover plate or the supported equipment and box.
- GG. Locate boxes so that cover or plate will not span different building finishes.
- HH. Set floor boxes level and flush with finished floor surface.
- II. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
- JJ. Provide stainless steel cover plates on all abandoned boxes that remain from selective demolition.
- KK. Cable pathway and firestop device: Install in locations where indicated on the plans. Arrange singly or in gangs and mounted above accessible ceilings. Install the devices in strict accordance with the manufacturer's recommendations.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout length elbow.
5. Transition from PVC-Schedule 80 (RNC) to RMC underground, no RNC conduit shall exposed outdoors or inside building.
6. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches of concrete.
 - b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
7. Underground Warning Tape: Comply with requirements in Section 26 0553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line 42" below grade.
- E. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 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 Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 07 8413 "Penetration Firestopping."

3.7 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.8 CLEANING

- A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 26 0533

SECTION 26 0536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes cable trays and accessories.

1.2 ACTION SUBMITTALS

- A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: 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.

1.3 INFORMATIONAL SUBMITTALS

- A. 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. Include 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.
- B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NEMA VE 1, "Metal Cable Tray Systems," if cable tray types specified are defined in the standard.
- D. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate layout and installation of cable trays and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Chalfant Manufacturing Company.
2. WBT, LLC
3. Cooper B-Line, Inc.
4. Cope, T. J., Inc.; a subsidiary of Allied Tube & Conduit.
5. MONO-SYSTEMS, Inc.
6. MPHusky.
7. PW Industries Legrand
8. Square D Company.
9. Cablofil Legrand
10. Thomas & Betts / A Member of the ABB Group

2.2 MATERIALS AND FINISHES

- A. Cable Trays, Fittings, and Accessories: Steel, with the following finish:

1.

2. Powder coated finish applied after fabrication.

- B. Cable Trays, Fittings, and Accessories: Aluminum, complying with Aluminum Association's alloy 6063-T6 for rails, rungs, and cable trays, and alloy 5052-H32 or alloy 6061-T6 for fabricated parts.
- C. Protect steel hardware against corrosion by galvanizing according to ASTM B 633 or cadmium plating according to ASTM B 766.
- D. Fabricate cable tray products with rounded edges and smooth surfaces.
- E. Sizes and Configurations: Refer to the Drawings for sizes, and configurations.

2.3 SIZES AND CONFIGURATIONS

- A. Ladder-Type Trays: Class 8C unless indicated. Single center support.

1. Width: 6 inches (152 mm).
2. Width: 12 inches (305 mm).
3. Width: 18 inches (457 mm).
4. Inside Depth: 4 inches (102 mm).
5. Cross-Rung Spacing: 9 inches (229 mm) o.c.
6. Minimum Fitting Radius: 24 inches (610 mm).

B. Channel-Type Trays: Use the following sizes:

1. Width: 6 inches (152 mm).
2. Minimum Fitting Radius: 24 inches (610 mm).
3. Tray Bottom: Ventilated.

C. Welded Wire Mesh cable management system.

1. Single rod, center hung support.
2. Width: 12 inches (305 mm).
3. Inside Depth: 4 inches (102 mm).
4. 2"x4" mesh.
5. Minimum Fitting Radius: 24 inches (610 mm).
6. Wire diameter: Vary to meet application load requirements to optimize tray strength.
7. NEMA VE 1 does not apply to this cable tray type.

D. Wire-Basket Cable Trays

1. Configuration: Wires are formed into a standard 2-by-4-inch (50-by-100-mm) wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.
2. Materials: High strength steel longitudinal wires with no bends.
3. Safety Provisions: Wire ends along wire-basket sides (flanges) rounded during manufacturing to maintain integrity of cables and installer safety.
4. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings. Pre-fabricated fittings shall be used.
5. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

2.4 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray. Fittings may be pre-fabricated by the manufacturer at the time of production.
- B. Cable tray supports and connectors, sway brace assemblies, and bonding jumpers, as recommended by cable tray manufacturer.
- C. Barrier Strips: Same materials and finishes as cable tray.
- D. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.5 WARNING SIGNS

- A. Lettering: 1-1/2-inch high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CABLE TRAY INSTALLATION

- A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
- B. Remove burrs and sharp edges from cable trays.
- C. Fasten cable tray supports to building structure.
 - 1. Design each fastener and support to carry load indicated by seismic requirements
 - 2. Place supports so that spans do not exceed maximum spans on schedules.
 - 3. 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.
 - 4. Support bus assembly to prevent twisting from eccentric loading.
 - 5. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
 - 6. Locate and install supports according to NEMA VE 2.
- D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
- E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
- F. Make changes in direction and elevation using standard fittings.

- G. Make cable tray connections using standard fittings.
- H. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping." Provide UL listed factory wall penetration. Install E90 certified cable tray (90 minute fire rated) for critical circuits, rated hallways or in areas of egress as shown on architectural drawings.
- I. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- J. Workspace: Install cable trays with enough space to permit access for installing cables.
- K. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- L. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.

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.
- 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 CABLE TRAY GROUNDING

- A. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Cable trays with electrical power conductors shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays shall be bonded together with a grounding conductor run in the tray and bonded to the tray at 72-inch intervals. The grounding conductor shall be sized according to NFPA 70, Article 250.122, "Size of Equipment Grounding Conductors," and Article 392, "Cable Trays."
- D. 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.

- E. 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."

3.5 FIELD QUALITY CONTROL

- A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
 - 1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
 - 2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
 - 3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.
 - 4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
 - 5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
 - 6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
- B. Report results in writing.

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 26 0536

SECTION 26 0544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS 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. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.
- B. Related Requirements:
 - 1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Exterior Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized sheet steel.
 - 2. Minimum Metal Thickness:

- a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
- b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 3. Pressure Plates: Carbon steel.
 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Presealed Systems.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.

1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 2. Sealant shall have VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 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.

END OF SECTION 26 0544

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Identification for raceways.
2. Identification of power and control cables.
3. Identification for conductors.
4. Underground-line warning tape.
5. Warning labels and signs.
6. Instruction signs.
7. Equipment identification labels.
8. Miscellaneous identification products.

1.2 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.3 QUALITY ASSURANCE

- A. Comply with ANSI A13.1.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.4 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage.
- C. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.2 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.3 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend, machine printed by thermal transfer or equivalent process.

2.4 NAMEPLATES AND SIGNS

- A. Engraved Plastic Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.
 - 1. Engraved legend with black letters on white face.

2. Punched or drilled for mechanical fasteners.

- B. Baked-Enamel Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.
- C. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for the application. 1/4-inch grommets in corners for mounting.
- D. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.5 UNDERGROUND-LINE WARNING TAPE

A. Tape:

- 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and 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 degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- 4. Not less than 6 inches wide by 4 mils thick.
- 5. Compounded for permanent direct-burial service.
- 6. Embedded continuous metallic strip or core.
- 7. Printed legend indicating type of underground line.

B. Color and Printing:

- 1. Comply with ANSI Z535.1 through ANSI Z535.5.
- 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
- 3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.6 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

- 1. Preprinted aluminum signs, 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.

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; 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.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.7 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.
- B. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- C. Stenciled Legend: In non-fading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.8 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select 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 INSTALLATION

- A. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Apply identification devices to surfaces that require finish after completing finish work.
- C. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- D. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

- E. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- F. Circuits with More Than 600 V: Identify raceway and cable with "DANGER--HIGH VOLTAGE" in black letters 2 inches high, stenciled with paint at 10-foot intervals over a continuous, painted orange background. Identify the following:
 - 1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
 - 2. Wall surfaces directly external to conduits concealed within wall.
 - 3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in the building, or concealed above suspended ceilings.
 - 4. Entire surface of exposed conduits.
- G. Install painted identification according to manufacturer's written instructions and as follows:
 - 1. Clean surfaces of dust, loose material, and oily films before painting.
 - 2. Prime surfaces using type of primer specified for surface.
 - 3. Apply one intermediate and one finish coat of enamel.
- H. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.
- I. Circuit Identification on Device Plates.
 - 1. Identify circuits feeding receptacles with the designation of the panelboard and the circuit number in permanent marker on the back of each device cover plate.
 - 2. In mechanical, technology closets, electrical rooms and industrial type spaces, provide typed self-adhesive plastic labeling on outside of cover-plate to indicate the circuit number.
- J. Circuit Identification Labels on Boxes: Install labels externally.
 - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 - 2. Concealed Boxes: Plasticized card-stock tags.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- L. Underground-Line Warning Tape: During backfilling of trenches, install continuous underground-line warning tape directly above line 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.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Install labels at 20-foot maximum intervals.

- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
1. Emergency Power.
 2. Power.
 3. UPS.
- C. Color-Coding of Secondary Phase Conductors: Use the following colors for service feeder and branch-circuit phase conductors:
1. 208/120-V Conductors:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 2. 480/277-V Conductors:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Slate/Gray.
 - e. Ground: Green.
 3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:
 - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch- wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
 - b. Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches from the terminal and spaced 3 inches apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length.
- D. Provide labelling of each independent, conductors at 50' maximum centers, label at equipment and label at bus bars. Separate ground conductors routed concealed within conduit shall have conduit labels to identify the grounding conductor equipment or grounding/bonding location.
- a. Indicate what equipment is fed or where the equipment is fed from on the label.
 - b. At service grounding bus bar, label "service grounding electrode conductor" at service entrance ground and label the equipment served by each equipment ground conductor.
- E. Apply identification to conductors as follows:
1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.

- F. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch- high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- G. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- H. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch- high letters for emergency instructions at equipment used for power transfer, load shedding and multiple services.
- I. Equipment Identification Labels: Engraved plastic laminate. Install on each unit of equipment, including central or master unit of each system. This includes power, lighting, communication, signal, and alarm systems, unless units are specified with their own self-explanatory identification. Unless otherwise indicated, provide a single line of text with 1/2-inch- high lettering on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high. Apply labels for each unit of the following categories of equipment using mechanical fasteners:
1. Panelboards, electrical cabinets, and enclosures.
 2. Access doors and panels for concealed electrical items.
 3. Electrical switchgear and switchboards.
 4. Electrical substations.
 5. Emergency system boxes and enclosures.
 6. Motor-control centers.
 7. Disconnect switches.
 8. Enclosed circuit breakers.
 9. Motor starters.
 10. Push-button stations.
 11. Boiler shut-offs.
 12. Power transfer equipment.
 13. Contactors.
 14. Remote-controlled switches.
 15. Dimmers.
 16. Control devices.
 17. Transformers.
 18. Power-generating units.
 19. Clock/program master equipment.
 20. Call system master station.
 21. Fire alarm control panel.
 22. Security-monitoring master station or control panel.

END OF SECTION 26 0553

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SECTION 26 0573.16 - COORDINATION STUDIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For computer software program to be used for studies.
 - 2. Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
 - a. Coordination-study input data, including completed computer program input data sheets.
 - b. Study and equipment evaluation reports.
 - 3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.
 - a. 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.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 - 1. For Power System Analysis Software Developer.
 - 2. For Power Systems Analysis Specialist.
 - 3. For Field Adjusting Agency.
- B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Studies shall be performed using commercially developed and distributed software designed specifically for power system analysis.

- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
- D. Power System Analysis Software Qualifications:
 - 1. Computer program shall be designed to perform coordination studies or have a function, component, or add-on module designed to perform coordination studies.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- E. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- F. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Comply with IEEE 242 and IEEE 399.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory" features as listed in IEEE 399.
- D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

2.2 COORDINATION STUDY REPORT CONTENTS

- A. Executive summary of study findings.
- B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of results.
- C. One-line diagram of modeled power system, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Conductor types, sizes, and lengths.

3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.
6. Any revisions to electrical equipment required by the study.
7. Study Input Data: As described in "Power System Data" Article.
 - a. Short-Circuit Study Output: As specified in "Short-Circuit Study Output Reports" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0573.13 "Short-Circuit Studies."

D. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the 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 the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the 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. Low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
 - c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
 - d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
 - e. Ground-fault protective devices.
 - f. The largest feeder circuit breaker in each motor-control center and panelboard.
5. Maintain selectivity for tripping currents caused by overloads.
6. Provide adequate time margins between device characteristics such that selective operation is achieved.
7. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance of the Work. Devices to be coordinated are indicated on Drawings.
 - 1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.2 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the overcurrent protective device study.
 - 1. Verify completeness of data supplied in one-line diagram on Drawings. Call any discrepancies to Architect's attention.
 - 2. For equipment included as Work of this Project, use characteristics submitted under provisions of action submittals and information submittals for this Project.
- B. Gather and tabulate all required input data to support the coordination study. List below is a guide. Comply with recommendations in IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

3.3 COORDINATION STUDY

- A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.
- B. Comply with IEEE 399 for general study procedures.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
 - 3. .
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
 - a. Inrush current when first energized.
 - b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
 - c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.
 2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.
- H. Motor Protection:
1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
 2. Select protection for motors served at voltages more than 600 V according to IEEE 620.
- I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.
- J. Generator Protection: Select protection according to manufacturer's written instructions and to IEEE 242.
- K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.
1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the 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 the report identification of any protective device applied outside its capacity.
- 3.4 FIELD ADJUSTING
- A. Adjust relay and protective device settings according to recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of equipment manufacturer under the "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 shall be by a full-time employee of the Field Adjusting Agency, who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.
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 all adjustable overcurrent protective devices.

3.5 DEMONSTRATION

A. Engage Power Systems Analysis Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in fundamentals of operating the power system in normal and emergency modes.
2. Hand-out and explain the coordination study objectives, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting time-current coordination curves.
3. For Owner's maintenance staff certified as NETA ETT-Certified Technicians Level III or NICET Electrical Power Testing Level III Technicians, teach how to adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION 26 0573.16

SECTION 26 0573.13 - SHORT-CIRCUIT STUDIES

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.2 ACTION SUBMITTALS

- A. Product Data:
 - 1. For computer software program to be used for studies.
 - 2. Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.
 - a. Short-circuit study input data, including completed computer program input data sheets.
 - b. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.
 - 1) 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.
 - 2) Revised one-line diagram, reflecting field investigation results and results of short-circuit study.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data:
 - 1. For Power Systems Analysis Software Developer.
 - 2. For Power System Analysis Specialist.
 - 3. For Field Adjusting Agency.
- B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.5 QUALITY ASSURANCE

- A. Study shall be performed using commercially developed and distributed software designed specifically for power system analysis.

- B. Software algorithms shall comply with requirements of standards and guides specified in this Section.
- C. Manual calculations are unacceptable.
 - 1. Power System Analysis Software Qualifications: Computer program shall be designed to perform short-circuit studies or have a function, component, or add-on module designed to perform short-circuit studies.
 - 2. Computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- D. Power Systems Analysis Specialist Qualifications: Professional engineer licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.
- E. Short-Circuit Study Certification: Short-Circuit Study Report shall be signed and sealed by Power Systems Analysis Specialist.
- F. Field Adjusting Agency Qualifications:
 - 1. Employer of a NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification responsible for all field adjusting of the Work.
 - 2. A member company of NETA.
 - 3. Acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 POWER SYSTEM ANALYSIS SOFTWARE DEVELOPERS

- A. <Double click here to find, evaluate, and insert list of manufacturers and products.>
- B. Comply with IEEE 399 and IEEE 551.
 - 1. Analytical features of power systems analysis software program shall have capability to calculate "mandatory" features as listed in IEEE 399.
- C. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

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 kilovolt ampere (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 the study.
- D. Comments and recommendations for system improvements or revisions in a 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.
- F. Short-Circuit Study Input Data:
1. One-line diagram of system being studied.
 2. Power sources available.
 3. Manufacturer, model, and interrupting rating of protective devices.
 4. Conductors.
 5. Transformer data.
- G. Short-Circuit Study Output Reports:
1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Equivalent impedance.
 2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.
 - b. Calculated symmetrical fault-current magnitude and angle.
 - c. Fault-point X/R ratio.
 - d. Calculated asymmetrical fault currents:
 - 1) Based on fault-point X/R ratio.
 - 2) Based on calculated symmetrical value multiplied by 1.6.
 - 3) Based on calculated symmetrical value multiplied by 2.7.
 3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
 - a. Voltage.

- b. Calculated symmetrical fault-current magnitude and angle.
- c. Fault-point X/R ratio.
- d. No AC Decrement (NACD) ratio.
- e. Equivalent impedance.
- f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
- g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.1 POWER SYSTEM DATA

- A. Obtain all data necessary for conduct of the study.
- B. Gather and tabulate the required input data to support the short-circuit study. Comply with requirements in Section 01 7839 "Project Record Documents" for recording circuit protective device characteristics. Record data on a Record Document copy of one-line diagram. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT-Certified Technician Level III or NICET Electrical Power Testing Level III certification.

3.2 SHORT-CIRCUIT STUDY

- A. Perform study following the general study procedures contained in IEEE 399.
- B. Calculate short-circuit currents according to IEEE 551.
- C. Base study on device characteristics supplied by device manufacturer.
- D. Extent of electrical power system to be studied is indicated on Drawings.
- E. Begin short-circuit current analysis at the service, extending down to system overcurrent protective devices as follows:
 - 1. To normal system low-voltage load buses where fault current is 10 kA or less.
 - 2. Exclude equipment rated 240 V ac or less when supplied by a single transformer rated less than 125 kVA.
 - 3. .
- F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.
- G. Include the 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 the fault-current dc decrement to address asymmetrical requirements of interrupting equipment.
- H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and a single line-to-ground fault at each equipment indicated on one-line diagram.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.
 - I. Include in the report identification of any protective device applied outside its capacity.

END OF SECTION 26 0573.13

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SECTION 26 0574 - OVERCURRENT PROTECTIVE DEVICE ARC-FLASH STUDY

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes a computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.2 ACTION SUBMITTALS

- A. Product Data: For computer software program to be used for studies.
- B. Other Action Submittals: Submit the following submittals after the approval of system protective devices submittals. Submittals shall be in digital form.
 - 1. Arc-flash study input data, including completed computer program input data sheets.
 - 2. Arc-flash study report; signed, dated, and sealed by a qualified professional engineer.
 - a. Submit study report based on final approval of the distribution equipment submittals.

1.3 CLOSEOUT SUBMITTALS

- A. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.
- B. Operation and Maintenance Procedures: In addition to items specified in Section 01 7823 "Operation and Maintenance Data," provide maintenance procedures for use by Owner's personnel that comply with requirements in NFPA 70E.

1.4 QUALITY ASSURANCE

- A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.
- B. Arc-Flash Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.
 - 1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.
- C. Arc-Flash Study Specialist Qualifications: Professional engineer in charge of performing the study, analyzing the arc flash, and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

- D. Field Adjusting Agency Qualifications: An independent agency, with the experience and capability to adjust overcurrent devices and to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

- A. Software Developers: Subject to compliance with requirements, available software developers offering software that may be used for the Work include, but are not limited to, the following:
 - 1. ESA Inc. (Easy Power)
 - 2. Operation Technology, Inc. (ETAP)
 - 3. Power Analytics, Corporation. (Paladin)
 - 4. SKM Systems Analysis, Inc.
- B. Comply with IEEE 1584 and NFPA 70E.
- C. Analytical features of device coordination study computer software program shall have the capability to calculate mandatory features as listed in IEEE 399.

2.2 ARC-FLASH STUDY REPORT CONTENT

- A. Executive summary.
- B. Study descriptions, purpose, basis and scope.
- C. One-line diagram, showing the following:
 - 1. Protective device designations and ampere ratings.
 - 2. Cable size and lengths.
 - 3. Transformer kilovolt ampere (kVA) and voltage ratings.
 - 4. Motor and generator designations and kVA ratings.
 - 5. Switchgear, switchboard, motor-control center and panelboard designations.
- D. Study Input Data: As described in "Power System Data" Article 3.3.
- E. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
- F. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."
- G. Arc-Flash Study Output:
 - 1. 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 – where applicable.
- e. Equivalent impedance.
- f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
- g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

H. Incident Energy and Flash Protection Boundary Calculations:

1. Arcing fault magnitude.
2. Protective device clearing time.
3. Duration of arc.
4. Arc-flash boundary.
5. Working distance.
6. Incident energy.
7. Hazard risk category.
8. Recommendations for arc-flash energy reduction.

I. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

2.3 ARC-FLASH WARNING LABELS

- A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems." Produce a 4-by-6-inch thermal transfer label of high-adhesion polyester for each work location included in the analysis. Arc flash labels to be compliant with latest version of NFPA 70E.
- B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:
 1. Location designation.
 2. Nominal voltage.
 3. Flash protection boundary.
 4. Site specific hazard risk category.
 5. Incident energy.
 6. Working distance.
 7. Engineering report number, revision number, and issue date.
- C. Labels shall be machine printed, with no field-applied markings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine Project overcurrent protective device submittals. Proceed with arc-flash study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to arc-flash study may not be used in study.

3.2 ARC-FLASH HAZARD ANALYSIS

- A. Comply with NFPA 70E and its Annex D for hazard analysis study.
- B. Preparatory Studies:
 - 1. Short-Circuit Study Output: As specified in "Short-Circuit Study Output" Paragraph in "Short-Circuit Study Report Contents" Article in Section 26 0572 "Overcurrent Protective Device Short-Circuit Study."
 - 2. Protective Device Coordination Study Report Contents: As specified in "Protective Device Coordination Study Report Contents" Article in Section 26 0573 "Overcurrent Protective Device Coordination Study."
- C. Calculate maximum and minimum contributions of fault-current size.
 - 1. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume no motor load.
 - 2. The maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.
- D. Calculate the arc-flash protection boundary and incident energy at locations in the electrical distribution system where personnel could perform work on energized parts.
- E. Include low-voltage equipment locations, except equipment rated 240-V ac or less fed from transformers less than 125 kVA.
- F. Safe working distances shall be specified for calculated fault locations based on the calculated arc-flash boundary, considering incident energy of 1.2 cal/sq.cm.
- G. Incident energy calculations shall consider the accumulation of energy over time when performing arc-flash calculations on buses with multiple sources. Iterative calculations shall take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors shall be decremented as follows:
 - 1. Fault contribution from induction motors should not be considered beyond three to five cycles.
- H. Arc-flash computation shall include both line and load side of a circuit breaker as follows:
 - 1. When the circuit breaker is in a separate enclosure.
 - 2. When the line terminals of the circuit breaker are separate from the work location.

- I. Base arc-flash calculations on actual overcurrent protective device clearing time. Cap maximum clearing time at two seconds based on IEEE 1584, Section B.1.2.

3.3 POWER SYSTEM DATA

- A. Obtain all data necessary for the conduct of the arc-flash hazard analysis.
 1. Verify completeness of data supplied on the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
 2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
- B. Electrical Survey Data: Gather and tabulate the following input data to support study.
 1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
 2. Obtain electrical power utility impedance at the service.
 3. Power sources and ties.
 4. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
 5. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
 6. Motor horsepower and NEMA MG 1 code letter designation.
 7. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.4 LABELING

- A. Apply one arc-flash label for 600-V ac, 480-V ac, and applicable 208-V ac panelboards and disconnects and for each of the following locations:
 1. Motor-control center.
 2. Low-voltage switchboard.
 3. Switchgear.
 4. Medium-voltage switch.
 5. Control panel.

3.5 APPLICATION OF WARNING LABELS

- A. Install the arc-fault warning labels under the direct supervision and control of the Arc-Flash Study Specialist.

END OF SECTION 26 0574

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SECTION 26 0800 - COMMISSIONING OF ELECTRICAL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes commissioning process requirements for electrical systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.
 - 2. Division 22 Section "Commissioning of Plumbing" for plumbing commissioning requirements.
 - 3. Division 23 Section "Commissioning of HVAC" for HVAC commissioning requirements.

1.2 ABBREVIATIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for list of abbreviations used in the Specifications and in the Commissioning Plan.

1.3 DEFINITIONS

- A. Refer to Division 01 Section "General Commissioning Requirements" for list of definitions used in the Specifications and in the Commissioning Plan.

1.4 COORDINATION

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

1.5 COMMISSIONING PROCESS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to the commissioning process.

1.6 COMMISSIONING TEAM RESPONSIBILITIES

- A. Provide information requested by the CxA for final commissioning documentation.
 - 1. Test reports
- B. Assist the CxA in all verification and functional performance tests.
- C. Refer to Division 01 Section "General Commissioning Requirements" for additional requirements pertaining to the contractor responsibilities.

1.7 SYSTEMS TO BE COMMISSIONED

- A. Any electrical equipment or systems that are monitored and or controlled by Building Management System will be commissioned with no sampling methods.
- B. Refer to Division 01 Section "General Commissioning Requirements" for electrical systems to be commissioned.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Refer to Division 01 Section "General Commissioning Requirements" for test equipment requirements.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Refer to Division 01 Section "General Commissioning Requirements" for meeting requirements.

3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. No commissioning checklists will be required to be completed by Electrical contractor.
- B. Refer to Division 01 Section "General Commissioning Requirements" for additional participation requirements for start-up, prefucntional checklists and initial checkout.

3.3 FUNCTIONAL PERFORMANCE TESTING

- A. Sampling: No sampling of any equipment will be permitted. All equipped or types referenced in Division 01 Section "General Commissioning Requirements" will be 100% sample rate regardless of qty or size of equipment or system.
- B. Refer to Division 01 Section "General Commissioning Requirements" for additional participation requirements for functional performance testing.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for approval procedures.

3.5 DEFERRED TESTING

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to deferred testing.

3.6 WRITTEN WORK PRODUCTS

- A. Refer to Division 01 Section "General Commissioning Requirements" for requirements pertaining to written work products related to the commissioning process.

END OF SECTION 26 0800

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SECTION 26 0923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Indoor occupancy switchbox-mounted occupancy and outdoor motion sensors.
4. Emergency lighting devices.

B. Related Requirements:

1. Division 26 Section "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.2 ACTION SUBMITTALS

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

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data

1.5 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

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

1. Douglas Lighting Controls
2. Intermatic, Inc.

3. Leviton Mfg. Company Inc.
4. Lighting Control and Design.
5. Lightolier Controls; a Genlyte Company.
6. Lithonia Lighting; Acuity Lighting Group, Inc.
7. Paragon Electric Co.; Invensys Climate Controls.
8. Square D; Schneider Electric.
9. TORK.
10. Touch-Plate, Inc.
11. Watt Stopper (The).

- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Rating: 20-A, 277-V ac.
2. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
4. Astronomic Time: All channels.
5. Battery Backup: For schedules and time clock.

- C. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Rating: 20-A, 277-V ac.
2. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
3. Astronomic time dial.
4. Eight-Day Program: Uniquely programmable for each weekday and holidays.
5. Skip-a-day mode.
6. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.2 OUTDOOR PHOTOELECTRIC SWITCHES

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

1. Douglas Lighting Controls
2. Intermatic, Inc.
3. Lighting Control and Design.
4. Lithonia Lighting; Acuity Lighting Group, Inc.
5. Novitas, Inc.
6. Paragon Electric Co.; Invensys Climate Controls.
7. Square D; Schneider Electric.
8. TORK.
9. Touch-Plate, Inc.
10. Watt Stopper (The).

- B. Description: Solid state, with DPST dry contacts rated for 1800-VA tungsten or 1000-VA inductive to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
 2. Time Delay: 15-second minimum, to prevent false operation.
 3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
 4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.
- C. Description: Solid state, with DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
 2. Time Delay: 30-second minimum, to prevent false operation.
 3. Lightning Arrester: Air-gap type.
 4. Mounting: Twist lock complying with IEEE C136.10, with base.

2.3 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Douglas Lighting Controls
 2. Hubbell Lighting.
 3. Leviton Mfg. Company Inc.
 4. Lighting Control and Design.
 5. Lithonia Lighting; Acuity Lighting Group, Inc.
 6. Novitas, Inc.
 7. Sensor Switch, Inc.
 8. TORK.
 9. Watt Stopper (The).
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.
 5. Sensors shall be rated for their environment. Sensors installed in damp environment not limited to shower rooms, locker rooms, outdoor areas, shall be provided with high humidity option. High humidity option shall be available by the manufacturer when required.
 6. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.

- b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 7. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 - 8. Bypass Switch: Override the on function in case of sensor failure.
 - 9. Automatic Light-Level Sensor: Adjustable from 10 to 300 fc; keep lighting off when selected lighting level is present.
- C. Dual Technology Type: Ceiling mounting; detect occupancy by sensing a combination of passive infrared heat and ultrasonic technologies in area of coverage.
- 1. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
 - 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.

2.4 SWITCH-BOX OCCUPANCY SENSORS

- A. Manufacturers:
- 1. Douglas Lighting Controls
 - 2. Hubbell Lighting Inc.
 - 3. Leviton Mfg. Company Inc.
 - 4. Lighting Control and Design.
 - 5. MYTECH Corporation.
 - 6. Novitas, Inc.
 - 7. Sensor Switch, Inc.
 - 8. TORK.
 - 9. Watt Stopper (The).
- B. Description: PIR type with integral power-switching contacts rated for 800 W at 120-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/6-hp motors; and rated for 1000 W at 277-V ac, suitable for incandescent light fixtures, fluorescent light fixtures with magnetic or electronic ballasts, or 1/3-hp motors, minimum.
- 1. Sensor shall cover 1000 square feet for major motion and 300 square feet for minor motion.
 - 2. Sensor shall have an audible warning that beeps before lights turn off automatically. This feature shall have the option of being disabled.
 - 3. Include ground wire.
 - 4. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; keeps lighting off when selected lighting level is present.
 - 5. Sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options.

2.5 DIGITAL OCCUPANCY SENSORS AND DIMMERS

- A. Manufacturers:

1. nLIGHT by Sensor Switch, An Acuity Brands Company.
2. Wattstopper.

B. Digital System Occupancy Sensors

1. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
2. All Sensors must be programmed for Vacancy Sensor operation for all rooms except for corridors and restrooms. Corridors and restrooms shall have the occupancy sensor turn the lights on when human activity is detected. The Digital Switch must be pressed for lighting to turn ON, and OFF. The sensor is for Automatic OFF ONLY.
3. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions. Ultrasonic or Microwave based sensing technologies shall not be accepted.
4. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.
5. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants. Sensors where both technologies detect motion (PIR/Ultrasonic) shall not be acceptable.
6. All sensing technologies shall be acoustically passive meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space (such as electronic white board readers). Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology. Ultrasonic or Microwave based sensing technologies shall not be accepted.
7. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Sensors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.
8. Sensors shall be available with one or two occupancy "poles", each of which provides a programmable time delay.
9. Sensors shall be available in multiple lens options which are customized for specific applications.
10. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
11. All sensors shall have two RJ-45 ports.
12. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5 connections) and blink its LED in a pattern to visually indicate of a potential wiring issue
13. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.
14. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5 cabling.
15. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.
16. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.
17. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.

18. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.
19. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray)
20. Wall switch sensors shall be the following Sensor Switch model numbers, with device color and optional features as specified. See Drawings for Details and Part Numbers.
21. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.
22. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
23. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
24. Sensors shall be the following Sensor Switch model numbers, with device options as specified: See Drawings for Details and Part Numbers.

C. Digital System Power (Relay) Packs

1. Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay(s), shall have an optional 2nd relay, 0-10 VDC dimming output, or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
3. All devices shall have two RJ-45 ports.
4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button.
5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass
7. through chase nipple into adjacent junction box without any exposure of wire leads.
8. Power (Secondary) Packs shall be available that provide up to 16 Amp switching of all load types, and be rated for 400,000 cycles.
9. Specific Secondary Packs shall be available that provide up to 5 Amps of switching as well as 0-10 VDC dimming of fluorescent ballasts.
10. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching of dual phase (208/240/480 VAC) lighting loads.
12. Specific Secondary Packs shall be available that require a manual switch signal (via a networked Wall Station) in order to close its relay.
13. When Required Specific Emergency Secondary Power Packs shall be available to provide switching up to 5 Amps at 120 or 277v and must hold a UL924 Listing.
14. Provide auxiliary relay for connection to building management system.
15. Power (Relay) Packs and Supplies shall be the following Sensor Switch model numbers: See Drawings for Details and Part Numbers.

D. Digital System Wall Switches & Dimmers

1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Devices shall be available with zero or one integrated Class 1 switching relay.
3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. All sensors shall have two RJ-45 ports.
5. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
6. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
7. Devices with dimming control outputs can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of current (typically 40 or more ballasts).
8. Devices with capacitive touch buttons shall provide audible user feedback with different sounds for on/off, raise/lower, start-up, and communication offline.
9. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
10. Devices with mechanical push-buttons shall be made available with custom button labeling
11. Devices with a single on button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.
12. Wall switches & dimmers shall be the following Sensor Switch model numbers, with device options as specified: See Drawings for Details and Part Numbers.

2.6 OUTDOOR MOTION SENSORS (PIR)

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- C. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 1. Bryant Electric; a Hubbell Company.
 2. Hubbell Lighting.
 3. Lighting Control and Design.
 4. Lithonia Lighting; Acuity Lighting Group, Inc.
 5. Paragon Electric Co.; Invensys Climate Controls.
 6. TORK.
 7. Watt Stopper (The).
- D. Performance Requirements: Suitable for operation in ambient temperatures ranging from minus 40 to plus 130 deg F, rated as raintight according to UL 773A.
 1. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outdoor junction box.
 - b. Relay: Internally mounted in a standard weatherproof electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 3. Bypass Switch: Override the on function in case of sensor failure.

4. Automatic Light-Level Sensor: Adjustable from 1 to 20 fc; keep lighting off during daylight hours.
- E. Detector Sensitivity: Detect occurrences of 6-inch- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in..
- F. Detection Coverage: Up to 35 feet, with a field of view of 90 degrees.
- G. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
- H. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 1. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 2. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

2.7 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Allen-Bradley/Rockwell Automation.
 2. ASCO Power Technologies, LP; a division of Emerson Electric Co.
 3. Eaton Electrical Inc.; Cutler-Hammer Products.
 4. Douglas Lighting Controls
 5. GE Industrial Systems; Total Lighting Control.
 6. Grasslin Controls Corporation; a GE Industrial Systems Company.
 7. Hubbell Lighting.
 8. Lighting Control and Design.
 9. Lithonia Lighting; Acuity Lighting Group, Inc.
 10. Square D; Schneider Electric.
 11. TORK.
 12. Touch-Plate, Inc.
 13. Watt Stopper (The).
- B. Description: Electrically operated and mechanically held, combination type with nonfused disconnect, complying with NEMA ICS 2 and UL 508.
 1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
 2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
 3. Enclosure: Comply with NEMA 250.
 4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.8 EMERGENCY LIGHTING DEVICES

A. Manufacturers:

1. Iota Engineering
2. LVS, Inc.
3. Philips Bodine

B. Description: Generator (or central inverter) supplied egress lighting shall be provided by using a fixture equipped with an emergency lighting device (sometimes referred to as a generator transfer device).

1. The device shall be capable of bypassing the wall switch or other lighting controls when the normal power fails to the fixture and transfer to emergency power.
2. Device shall operate at 120 or 277 VAC, 60 Hz;
3. Device shall comply with the NEC.
4. The device shall be UL 924 Listed for installation inside, on top of or remote from the fixture.
5. In a DALI system, the system shall be UL 924 and programmed to turn on affected zones when a power loss is detected and to fail closed. ELD devices are not required with a DALI, UL 924 listed system when configured to meet emergency lighting requirements upon branch circuit power failure.
6. The device shall be warranted for a full five years from date of purchase.

2.9 EMERGENCY SHUNT RELAY

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

1. Lighting Control and Design, Inc.

B. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.

1. Coil Rating: 120 V.

2.10 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No.14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.
- B. Install ceiling mounted sensors in the center of the lay-in ceiling tile when available.
- C. Install power packs above the accessible ceiling at the light switch location in room. If room does not have accessible ceiling and the adjacent corridor does, then install on corridor side. Install power pack in junction box to conceal the termination if installed on an exposed ceiling.
- D. Install according to manufacturer's recommendations.

3.2 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch. All low voltage and communication cabling shall be run in conduit, refer to Section 26 0533 – Raceways and Boxes for Electrical Systems.
- B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- C. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- D. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

- B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 - 2. Operational Test: Verify actuation of each sensor and adjust time delays.
- B. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.
- C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.6 ADJUSTING

- A. Adjust time delay on each sensor to 15 minutes unless noted otherwise on plans.
- B. Coordinate light sensor level with owner to determine preferred operating range.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

END OF SECTION 26 0923

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SECTION 26 0943.23 - LIGHTING CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish and install a complete system for the control of lighting and other equipment as indicated on the plans, detailed in the manufacturer submittal and as further defined herein. Contractor is solely responsible to verify quantity, installation locations and wiring requirements for this project. Specific manufacturer's catalog numbers, when listed in this section are for reference only. It is the responsibility of the contractor to verify with lighting control manufacturer all catalog information and specific product acceptability.
- B. The system shall include but not be limited by the following list: Pre-wired, microprocessor controlled relay panels with electrically held, electronically latched relays panels controlled via a complete list of communication based accessories including digital switches, digital photocells, digital SmartBreaker panelboards, Digital Time Clock (DTC) and interface cards to dimming systems, building automation systems, thermostats, and other devices. The type of lighting control equipment and wiring specified in this section is covered by the description: Microprocessor Controlled Digital Relay Lighting Control system with RS 485 Bus communications. Requirements are indicated elsewhere in these specifications for work including, but not limited to, raceways and electrical boxes and fittings required for installation of control equipment and wiring.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For each relay panel and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail wiring partition configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of relays.
 - 5. Include diagrams for power, signal, and control wiring.
 - 6. Product data for UPS supplied at each control panel.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - 1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
 - 3. Provide elevation of lighting control panels mounted on wall. Orient stacked and minimize wall space usage, consolidate into larger panels as feasible to keep future wall space for future added panels.

- B. Field quality-control reports.
- C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- D. Sample warranty.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panels for installation according to NECA 407.

1.6 QUALITY ASSURANCE

- A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
- E. Comply with NFPA 70.
- F. Lighting control relay panels shall be UL 916 Listed.
- G. Lighting control relay panels controlling emergency circuits shall be ETL listed to UL 924. Emergency source circuits controlled in normal operation by a relay panel shall fully comply with NEC 700-9(b). Electrical contractor to verify compliance.
- H. The lighting control system shall also be listed or approved by all national, state and local energy codes to include but not limited to California Title 24 and ASHRAE 90.1-2007.

1.7 COORDINATION

- A. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of lighting control functions.
 - 2. Coordinate lighting controls with HVAC controls. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
 - 3. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
 - 4. Coordinate with fire alarm system, provide signal to turn on emergency lighting circuits in the event of a fire alarm.
- B. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards."

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of software input/output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.
 - c. Damage of electronic components due to transient voltage surges.
 - 2. Warranty Period: Two years from date of Substantial Completion.
 - 3. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.
 - 4. Extended Warranty Period for Electrically Held Relays: 10 years from date of Substantial Completion.

1.9 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Manual Switches: Provide 5 additional single stations and 5 additional two button stations.

1.10 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 the 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

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. nLight Networked Lighting Controls Platform (DALI)
 2. Douglas Lighting Control
 3. Intelligent Lighting Controls, Inc.
 4. Leviton Mfg. Company Inc.
 5. Lighting Control & Design, Inc.
 6. Lightolier Controls; a Genlyte Company.
 7. Lithonia Lighting; Acuity Lighting Group, Inc.
 8. Lutron Electronics Company, Inc.
 9. MicroLite Lighting Control Systems.
 10. NexLight; Northport Engineering Group.
 11. Starfield Controls, Inc.
 12. Touch-Plate, Inc.
 13. Watt Stopper (The).

2.2 SYSTEM REQUIREMENTS

- A. The lighting control system is a networked system that communicates via RS485. The system must be able to communicate with fully digital centralized relay panels, micro relay panels, smart breaker panels, digital switches, photocells, various interfaces and shall include all operational software. The intent of the specification is to integrate all lighting control into one system, except for areas controlled by a single motion sensor such as rooms with a single luminaire and emergency fixtures designed to operate 24/7. Distributed lighting control shall be provided using a networked micro relay panel. A centralized relay panel shall control corridors and site lighting. Lighting control system shall include all hardware and software. Software to be resident within the lighting control system. System shall provide local access to all programming functions at the master LCP and remote access to all programming functions via dial up modem and through any standard computer workstation running an industry standard internet browser. Lighting control system shall have server built into the master LCP that "serves" HTML pages to any authorize workstation. Desktop computers are not part of this section and will be provided by others. Non-networked, non-digital, non-server capable systems not acceptable.
- B. System software shall provide real time status of each relay, each zone and each group.
- C. Lighting control system shall be able to be monitored by and take commands from a remote PC. At any time, should the remote PC go off-line all system programming uploaded to the lighting control system shall continue to operate as intended. Systems requiring an on line PC or server for normal operation are not acceptable
- D. All devices shall be pre-addressed at the factory. Field addressing is not acceptable.
- E. All programs, schedules, time of day, etc, shall be held in non-volatile memory for a minimum of 10 years at power failure. At restoration of power, lighting control system shall implement programs required by current time and date.
- F. System shall be capable of flashing lights Off/On any relay or any zone prior to the lights being turned Off. The warning interval time between the flash and the final lights off signal shall be definable for each zone.

Occupant shall be able to override any scheduled Off sweep using local wall switches within the occupied space. Occupant override time shall be locally and remotely programmable and not exceed 2-hours.

- G. The system shall be capable of implementing On commands, Off commands, Raise (dimming) commands, Lower (dimming) commands for any relay, group or zone by means of digital wall switches, specification grade line voltage type wall switches, photocell, web based software or other devices connected to programmable inputs in a lighting control panel.
- H. The lighting control system shall provide the ability to control each relay and each relay group per this specifications requirement. All programming and scheduling shall be able to be done locally at the master LCP and remotely via dial up modem and via the Internet. Remote connection to the lighting control system shall provide real time control and real time feedback.
- I. System may consist of centralized relay panels, micro relay panels, smart breaker panels, digital switches, photocells and various digital interfaces. Verify exact components specified. Micro relay panels, smart breaker panels, centralized relay panels and digital switches shall communicate as one network via RS485. Micro relay panels, mounted in each local area, per plans shall control all lighting fixtures in that space, provide power to occupancy sensors and take input from daylight sensor and occupancy sensors. Micro relay panels shall be capable of taking inputs from standard, line voltage type switches and outputting up to 8 independent 0v to 10v dimming signals. All micro relay panels and all devices connected to micro relay panels (switches, photocells and occupancy sensors, etc) shall be wired per lighting control manufacturers instructions.
- J. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, terminals, number of conductors in control cables, and control software.
- K. UPS: Provide with uninterruptable power supply battery system at each lighting control panel. Size as required for the panel power requirements with 40% spare capacity.

2.3 RELAY PANELS

- A. NEMA rated enclosure with screw cover or hinged door. Other NEMA types optional.
- B. 16 AWG steel barrier shall separate the high voltage and low voltage compartments of the panel and separate 120v, 277v and emergency circuits.
- C. LCP input power shall be capable of accepting 120v or 277v without rewiring
- D. Control electronics in the low voltage section shall be capable of driving 2 to 48, 30a, 18,000 SCCR rated latching relays, control any individual or group of relays, provide individual relay overrides, provide a master override for each panel, store all programming in non-volatile memory, after power is restored return system to current state, provide programmable blink warn timers for each relay and every zone, and be able to control relays that default to Open, Normally Open Latching (NOL) or relays that default to Closed, Normally Closed Latching (NCL).
- E. Lighting control system shall be digital and consist of a Master LCP, Slave LCPs, Micro LCPs with up to 8 individual relays, digital switches, digital interface cards and if required, SmartBreaker panelboards. All system components shall connect and be controlled via a single Category 5, 4 twisted pair cable with

RJ45 connectors, providing real time two-way communication with each system component. Analog systems are not acceptable.

- F. The lighting control system is a networked system that communicates via RS485 and includes centralized relay panels, micro relay panels, digital switches, photocells, various interfaces and operational software. The intent of the specification is to integrate all lighting control into one system. Lighting control system shall include all hardware and software. Software to be resident within the lighting control system. System shall provide local access to all programming functions at the DTC and remote access to all programming functions via dial up modem and through any standard computer workstation running an industry standard internet browser. Lighting control system shall have server built into the master LCP that "serves" HTML pages to any authorized workstation. Desktop computers are not part of this section and will be provided by others. Non-networked, non-digital system not acceptable.

2.4 MICRO RELAY PANELS

- A. Micro relay panels shall have up to 8-30a, 18,000 SCCR rated lighting relays and shall control all lighting in the designated area indicated on the plans and be networked to centralized relay panels, micro relay panels, smart breaker panels, digital switches, photocells, various interfaces. Each micro relay panel shall provide minimum 300ma at 12/24vdc for powering occupancy sensors. Micro relay panels that require a separate occupancy sensor power pack are not acceptable.
- B. Micro relay panel shall provide a minimum 4-programmable photocell inputs, a minimum 4-programmable occupancy sensor inputs and matrixed contact closure inputs. This requirement is to insure integration of entire lighting system into one networked, lighting control system.
- C. Micro relay panels shall be capable of outputting minimum 4 and up to 8 independent 0v to 10v dimming signals, one independent dimming signal at each of 8 relays. In order to maximize daylight harvesting and minimize disruption to occupants, each dimming output shall provide adjustment for baseline, start point, mid point, end point, trim, fade up rate, fade down rate, time delay and enable/disable masking. All photocell setting must be remotely accessible. Systems providing On, Off with Time Delay only, and system that do not provide remote access are not acceptable.

2.5 STANDARD OUTPUT RELAYS

- A. UL Listed 30 Amp, Latching, 18,000 SCCR, 277VAC Ballast and HID and 20 Amp Tungsten at 120 Vac.
- B. Relays shall be individually replaceable. Relay terminal blocks shall be capable of accepting two (2) #8AWG wires on both the line and the load side. Systems that do not allow for individual relay replacement or additions are not acceptable.
- C. Relays to be rated for 250,000 operations minimum at a full 30a lighting load, default to closed at normal power loss, Normally Closed Latching (NCL). All incandescent circuits shall be energized by use of a Normally Closed SoftStart™ (NCSS) relay rated at 100,000 operations at full 20a load. No exceptions.
- D. Optional relay types available shall include: Normally Open Latching (NOL) relay rated for 250,000 operations, a 600v 2-pole NO and NC and a Single Pole, Double Throw (SPDT) relay.

2.6 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Modular, momentary-contact, low-voltage type.
 - 1. Match color specified in Division 26 Section "Wiring Devices."
 - 2. Integral green LED pilot light to indicate when circuit is on.
- B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Division 26 Section "Wiring Devices."
- C. Wall Plates: Single and multigang plates as specified in Division 26 Section "Wiring Devices."
- D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.
- E. All switches shall be digital and communicate via RS 485. Contact closure style switches, except as specified for connection to the micro relay panel matrixed contact closure inputs, shall not be acceptable. The programming for a digital switch will reside in the switch itself, via double EPROM memory. Any digital switch button function shall be able to be changed locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet.
- F. Digital low voltage switch shall be a device that sits on the lighting control system bus. Digital switch shall connect to the system bus using the same cable and connection method required for relay panels. System shall provide capability to locally and remotely program each individual switch button, monitor and change function of each button locally and remotely. Each button shall be capable of being programmed for On only, Off only, On/Off (toggle), Raise (Dim up) and Lower (Dim down). Switches shall also be capable of being disabled for specified times. Switches requiring low voltage control wires to be moved from one input terminal to another to accomplish these functions are not acceptable.
- G. Digital switches for high abuse areas (common areas, atrium, etc.) shall be vandal resistant, contain no moving parts, and be touch sensitive and available with up to three buttons in a single gang. Multi gang versions shall also be available. Touch pads shall be Stainless Steel and capable of handling both high abuse and wash down locations. High abuse switches shall connect to the lighting control system digital bus. Each high abuse switch touch button shall be able to be control any relay or any group in any panel or panels that is part of the lighting control system. Each touch button shall be able to be programmed for On, Off, Toggle or Maintain operation. All programming shall be done locally or remotely via dial up modem or web interface as described in other paragraphs of this section. High abuse switches shall be able to be enabled or disabled digitally. Each touch pad is to be identified as to function by an engraved label. Switches must be capable of handling electrostatic discharges of at least 30,000 volts (1cmspark) without any interruption or failure in operation.

2.7 DTC - Digital Electronic Time Clock

- A. A Digital Time Clock (DTC) shall control and program the entire lighting control system and supply all time functions and accept interface inputs.
- B. DTC shall be capable of up to 32 schedules. Each schedule shall consist of one set of On and Off times per day for each day of the week and for each of two holiday lists. The schedules shall apply to any individual relay or group of relays.

- C. The DTC shall be capable of controlling up to 126 digital devices on a single bus and capable of interfacing digitally with other individual busses using manufacturer supplied interface cards.
- D. The DTC shall accept control locally using built in button prompts and use of a 8 line 21-letter display or from a computer or modem via an on-board RS 232 port. All commands shall be in plain English. Help pages shall display on the DTC screen.
- E. The DTC shall be run from non-volatile memory so that all system programming and real time clock functions are maintained for a minimum of 15 years with loss of power.
- F. Pre-installed Unity™ lighting control software shall provide via local or remote PC a visual representation of each device on the bus, show real time status and the ability to change the status of any individual device, relay or zone. System shall be capable of running optional Unity GX lighting control software, which shall provide for directly importing vector based graphics. No exceptions.
- G. Pre-Installed modem that allows for remote programming from any location using a PC. Modem to include all necessary software for local or remote control.
- H. DTC shall provide system wide timed overrides. Any relay, group or zone that is overridden On, before or after hours, shall automatically be swept Off by the DTC a maximum of 2 hours later.

2.8 PHOTOCCELL

- A. Photocells to be mounted in location indicated on the plans. Photocells used for exterior lights shall provide multiple trips point from 1 roof mounted unit. All trips points shall be able to be changed remotely via Internet or dial up modem. Photocells requiring manual trip point adjustment are not acceptable. Photocell used for interior lighting control shall have multiple settings such as start-point, mid-point, off-point, fade-up, fade-down, etc. All settings shall be remotely accessible and adjustable. Systems providing local adjustment only are not acceptable. Photocells to be certified to comply with the current energy code covering this project at time of submittal of plans for building permit.

2.9 INTERFACES

- A. For future expansion capability, system to have available all of the following interfaces:
 - 1. A dry contact input interface card that provides 14 programmable dry contact closure inputs. Use shielded cable to connect input devices to interface card.
 - 2. Interface card providing digital communication from one system bus to another system bus, allowing up to 12,000 devices to communicate.
 - 3. An interface card that allows the DTC to control up to 32 digital XCI brand thermostats. Programming of thermostats to be able to done locally (at the DTC or a PC) or remotely, via modem, Internet or Ethernet.
 - 4. A voice prompted telephone override interface module. Interface module shall accept up to 3 phone lines and allow up to 3 simultaneous phone calls. Voice prompted menu and up to 999 unique pass codes shall be standard with each interface module.
 - 5. Software pre-installed to run Unity GX Graphical Interface Software. Unity GX software shall provide via local or remote PC a visual representation of a specific area or the total area of the project. GX full graphic pages shall be designed to the owner's specifications. Owner to provide to manufacturer all necessary files and criteria

6. Direct digital interface to SmartBreaker panelboards. Relay panel and SmartBreaker panelboard circuits shall appear on the system software as similar, yet distinct, items and maintain all functions and features of the system software.
7. Direct digital interface to DMX 512 based systems. DMX interface shall provide 14 global commands, each of which can be modified locally or remotely using lighting controls manufacturer supplied software. DMX interface shall be integral to the system bus and shall connect and be controlled via a single Category 5, 4 twisted pair cable, providing real time response from the lighting control system to DMX commands.
8. Direct digital interface to building automation systems using DDC protocols such as BACnet, Metasys (N2), LonWorks, ModBus, etc that accept on/off commands, time schedules and report status of all relays in all panels in real time. Coordinate all interface requirements with the BAS provider. Interface cards shall "self populate" each individual relay and each group to the BAS. All BAS system programming required shall be the responsibility of the BAS system provider.

2.10 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 16 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5 for horizontal copper cable.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panels according to NECA 407.
- B. Examine panels before installation. Reject panels that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panels 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 WIRING 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 except in unfinished spaces. Minimum conduit size shall be ½ inch.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for cable trays specified in Section 26 0536 "Cable Trays for Electrical Systems."
3. Comply with requirements for raceways and boxes specified in Section 26 0533 "Raceways and Boxes for Electrical Systems."

3.3 PANEL INSTALLATION

- A. Comply with NECA 1.
- B. Install panels and accessories according to NECA 407.
- C. Mount panel cabinet plumb and rigid without distortion of box.
- D. Install filler plates in unused spaces.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 0553 "Identification for Electrical Systems."
- C. Create a directory to indicate loads served by each relay; incorporate Owner's final room designations. Obtain approval before installing. Use a PC or typewriter to create directory; handwritten directories are unacceptable.
- D. Lighting Control Panel Nameplates: Label each panel with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- E. Provide a point-to-point wiring diagram for the entire lighting control system. Diagram must indicate exact mounting location of each system device. This accurate "as built" shall indicate the loads controlled by each relay and the identification number for that relay, placement of switches and location of photocell. Original to be given to owner, copies placed inside the door of each LCP.

3.5 INSTALLATION AND SET-UP

- A. Verify that conduit for line voltage wires enters panel in line voltage areas and conduit for low-voltage control wires enters panel on low-voltage areas. Refer to manufacturer's plans and approved shop drawings for location of line and low-voltage areas. It is the responsibility of the contractor to verify with lighting control manufacturer all catalog information and specific product acceptability.
- B. For approved line voltage type micro relay panel switches connected to matrixed inputs of the micro relay panel, furnish #18 AWG solid conductors. For all other digital switches provide wiring required by system manufacturer.
- C. For classroom digital switches provide wiring required by system manufacturer

- D. Contractor to test all low voltage cable for integrity and proper operation prior to turn over. Verify with system manufacturer all wiring and testing requirements.
- E. Before Substantial Completion, arrange and provide a one-day Owner instruction period to designated Owner personnel. Set-up, commissioning of the lighting control system, and Owner instruction includes:
 - 1. Confirmation of entire system operation and communication to each device.
 - 2. Confirmation of operation of individual relays, switches, occupancy sensors and daylight sensors
 - 3. Confirmation of system Programming, photocell settings, override settings, etc.
 - 4. Provide training to cover installation, maintenance, troubleshooting, programming, and repair and operation of the lighting control system.
- F. Panels shall be located so that they are readily accessible and not exposed to physical damage.
- G. Panel locations shall be furnished with sufficient working space around panels to comply with the National Electrical Code.
- H. Panels shall be securely fastened to the mounting surface by at least 4 points.
- I. Unused openings in the cabinet shall be effectively closed.
- J. Cabinets shall be grounded as specified in the National Electrical Code.
- K. Lugs shall be suitable and listed for installation with the conductor being connected.
- L. Conductor lengths shall be maintained to a minimum within the wiring gutter space. Conductors shall be long enough to reach the terminal location in a manner that avoids strain on the connecting lugs.
- M. Maintain the required bending radius of conductors inside cabinets.
- N. Clean cabinets of foreign material such as cement, plaster and paint.
- O. Distribute and arrange conductors neatly in the wiring gutters.
- P. Follow the manufacturer's torque values to tighten lugs.
- Q. Before energizing the panelboard, the following steps shall be taken:
 - 1. Retighten connections to the manufacturer's torque specifications. Verify that required connections have been furnished.
 - 2. Remove shipping blocks from component devices and the panel interior.
 - 3. Remove debris from panelboard interior.
- R. Follow manufacturers' instructions for installation and all low voltage wiring.
- S. Service and Operation Manuals:
 - 1. Submit operation and service manuals. Complete manuals shall be bound in flexible binders and data shall be typewritten or drafted.
 - 2. Manuals shall include instructions necessary for proper operation and servicing of system and shall include complete wiring circuit diagrams of system, wiring destination schedules for circuits and replacement part numbers. Manuals shall include as-built cable Project site plot plans and floor

plans indicating cables, both underground and in each building with conduit, and as-built coding used on cables. Programming forms of systems shall be submitted with complete information.

- T. Comply with energy code lighting control system "Acceptance Requirements". Acceptance tests are used to verify that lighting controls were installed and calibrated correctly. These tests may require that a responsible party certify that controls are installed and calibrated properly. This is the installing contractors responsibility. Verify requirements with building authority.

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- D. Lighting control panel will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies lighting control panels and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Confirm correct communications wiring, initiate communications between panels, and program the lighting control system according to approved configuration schedules, time-of-day schedules, and input override assignments.
- B. Provide factory-authorized personal for the following lighting control services:
 - 1. Provide programming time including feedback and site visit with Owner present to program the zones and times with owner input. Notify Engineer what date and time is set up for programming session for optional attendance.
 - 2. Provide lighting controls on-site commissioning and coordination with electrical contractor after initial programming and before building is occupied.
 - a. Provide at least 3 days for a building less than 30,000 square foot.
 - b. Provide at least 5 days for a building less than 200,000 square foot.

3. Provide up to (8) hours of owner training with Owner present.
4. Provide additional time after substation completion and within 30 days of owner Final Acceptance to make one-set of Owner requested changes.

3.8 ADJUSTING

- A. Owner Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in programming scheduling, dimming and adjusting sensors and to assist Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- B. Occupancy sensors shall be adjusted for seamless operation, contractor will have to move sensor and adjust settings at no charge due to faulty operation of the sensor due to location or settings for up to 12 months from date of Substantial Completion.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 0943.23

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SECTION 26 1200 - MEDIUM-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following types of transformers with medium-voltage primaries:
 - 1. Pad-mounted, liquid-filled transformers.

1.2 DEFINITIONS

- A. NETA ATS: Acceptance Testing Specification.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type and size of transformer indicated.
- B. Shop Drawings: Diagrams including power and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Source quality-control test reports.
- C. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Include dated documentation of torque values on all equipment.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
 - 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of transformers and are based on the specific system indicated. Refer to Section 01 6000 "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with IEEE C2.
- E. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.
- F. Comply with NFPA 70.
- G. All transformers to be DOE 2016 compliant.

1.7 PROJECT CONDITIONS

- A. Service Conditions: IEEE C37.121, usual service conditions.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Coordinate installation of louvers, doors, spill retention areas, and sumps. Coordinate installation so no piping or conduits are installed in space allocated for medium-voltage transformers except those directly associated with transformers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Industries; Cooper Power Systems Division.
 - 2. Cutler-Hammer.
 - 3. GE Electrical Distribution & Control.
 - 4. Siemens Energy & Automation, Inc.
 - 5. Square D/Group Schneider NA.
 - 6. Industrial Electric Mfg.
 - 7. Maddox Industrial Transformer

2.2 LIQUID-FILLED DISTRIBUTION AND POWER TRANSFORMERS

- A. Description: Comply with IEEE C57.12.00 and UL 1062 for liquid-filled, 2-winding transformers.
- B. Energy Efficiency: Transformer must be DOE 2016 compliant.

- C. Insulating Liquid: Mineral oil, ASTM D 3487, Type II; tested according to ASTM D 117.
- D. Insulating Liquid: Less flammable, edible-seed-oil based, and listed by a NRTL acceptable to authority having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
- E. Insulating Liquid: Less flammable, dielectric, and listed by a NRTL acceptable to authority having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.
- F. Insulating Liquid: Less flammable, silicone-based dielectric, and listed by a NRTL acceptable to authority having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
- G. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
- H. Basic Impulse Level: Comply with UL 1062.
- I. Full-Capacity Voltage Taps: Four, 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable, de-energized tap changer; position indicator; and padlock hasp.
- J. Cooling System: Class OA, self-cooled.
- K. Accessories:
 - 1. Grounding pads, lifting lugs, and provisions for jacking under base.
 - 2. Insulated, low-voltage, neutral bushing with removable ground strap.
 - 3. Liquid-level gage.
 - 4. Pressure-vacuum gage.
 - 5. Liquid temperature indicator.
 - 6. Drain and filter valves.
 - 7. Pressure relief device.

2.3 DRY-TYPE DISTRIBUTION AND POWER TRANSFORMERS

- A. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.50, ANSI C57.12.51, ANSI C57.12.52, UL 1562 listed and labeled, dry-type, 2-winding transformers.
 - 1. Indoor, ventilated cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
- B. Primary Connection: Air terminal compartment with removable door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
- C. Secondary Connection: Air terminal compartment with removable door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.
- D. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.

- E. Insulation Temperature Rise: 80 deg C, maximum rise above 40 deg C.
- F. Basic Impulse Level: 75 kV.
- G. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- H. Cooling System: Class AA/FA, self-cooled, and with forced-air-cooled rating, complying with IEEE C57.12.01.
 - 1. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
- I. Low-Sound Level Transformers: Sound level rating a minimum of 3 dB less than NEMA TR 1 standard sound levels for the transformer type and rating.
- J. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.
- K. Coils shall be wound with aluminum conductors.

2.4 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

- A. Description: ANSI C57.12.13, IEEE C57.12.00, IEEE C57.12.26, pad-mounted, 2-winding transformers. Stainless steel base strut under tank where tank touches concrete.
- B. Energy Efficiency: Transformer must be DOE 2016 compliant.
- C. Insulating Liquid: Envirotemp FR3 biodegradable, and listed by a NRTL acceptable to authority having jurisdiction as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. ASTM D6871-03 compliant. Liquid shall be biodegradable and nontoxic.
- D. Insulation Temperature Rise: 75 degree C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.
- E. Basic Impulse Level: 72 kV.
- F. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
- G. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment.
- H. High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:
 - 1. Bushing-Well Inserts: One for each high-voltage bushing well.
 - 2. Parking Well: Grounded for each high-voltage termination.

3. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.

I. Accessories:

1. Grounding pads, lifting lugs, and provisions for jacking under base.
2. Insulated, low-voltage, neutral bushing with removable ground strap.
3. External Drain Valve: 1 inch
4. External Instrumentation (on high voltage side) With separate hinged cover with padlock provisions.
5. External sampling device.
6. External Dial-type thermometer.
7. External Liquid-level gage.
8. External Pressure-vacuum gage.
9. External Pressure Relief Device: Self-sealing with an indicator.

- J. Coils shall be wound with manufacturer recommended material for conductors.

2.5 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.6 SOURCE QUALITY CONTROL

- A. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.50, ANSI C57.12.51, IEEE C57.12.90, IEEE C57.12.91.
- B. Factory Tests: Perform the following factory-certified tests on each transformer:
1. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
 2. Ratios on rated-voltage connection and on tap extreme connections.
 3. Polarity and phase relation on rated-voltage connection.
 4. No-load loss at rated voltage on rated-voltage connection.
 5. Excitation current at rated voltage on rated-voltage connection.
 6. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
 7. Applied potential.
 8. Induced potential.
 9. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
 - a. Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for medium-voltage transformers.
- B. Examine roughing-in of conduits and grounding systems to verify the following:
 - 1. Wiring entries comply with layout requirements.
 - 2. Entries are within conduit-entry tolerances specified by manufacturer and no feeders will have to cross section barriers to reach load or line lugs.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and that requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install transformers on concrete bases.
 - 1. Construct concrete bases not less than 4 inches larger in both directions than supported unit.
 - 2. Use 3000-psi , 28-day compressive-strength concrete and reinforcement as specified in Division 03 "Cast-in-Place Concrete".
 - 3. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
 - 4. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
 - 5. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- B. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

3.3 IDENTIFICATION

- A. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
 - 2. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.2. Certify compliance with test parameters.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove malfunctioning units, replace with new units, and retest as specified above.
- C. Test Reports: Prepare written reports to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.

3.6 FOLLOW-UP SERVICE

- A. Voltage Monitoring and Adjusting: If requested by Owner, perform the following voltage monitoring after Substantial Completion but not more than six months after Final Acceptance:
 - 1. During a period of normal load cycles as evaluated by Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
 - 2. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
 - a. Adjust transformer taps.
 - b. Prepare written request for voltage adjustment by electric utility.
 - 3. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
 - 4. Report: Prepare written report covering monitoring and corrective actions performed.
- B. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

END OF SECTION 26 1200

SECTION 26 1300 - MEDIUM-VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes pad mounted switchgear and three phase sectionalizing enclosures with the following optional components, features, and accessories:
 - 1. Main bus rated per drawings and specifications.
 - 2. Three-phase, dead-front
 - 3. Surge arresters.
 - 4. Provisions for future devices.

1.3 DEFINITIONS

- A. ATS: Acceptance Testing Specifications.
- B. GFCI: Ground-Fault Circuit Interrupter.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of switchgear and related equipment, include the following:
 - 1. Rated capacities, operating characteristics, furnished specialties, and accessories for individual interrupter switches.
 - 2. Time-current characteristic curves for overcurrent protective devices, including fusible devices.
- B. Shop Drawings: For each type of switchgear and related equipment, include the following:
 - 1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show method of field assembly and location and size of each field connection. Include the following:
 - a. Tabulation of installed devices with features and ratings.
 - b. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.
 - c. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
 - d. Floor plan drawing showing locations for anchor bolts and leveling channels.
 - e. Current ratings of buses.
 - f. Short-time and short-circuit ratings of switchgear assembly.
 - g. Nameplate legends.

2. Wiring Diagrams: For each type of switchgear and related equipment, include the following:
 - a. Power, signal, and control wiring.
 - b. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
 - c. Schematic control diagrams.
 - d. Diagrams showing connections of component devices and equipment.
- C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where piping and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Identify field measurements.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency.
- B. Source quality-control test reports.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For switchgear and switchgear components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. 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.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Include dated documentation of torque values on all equipment.

1.7 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.
- B. Source Limitations: Obtain each type of switchgear and associated components through one source from a single manufacturer.
- C. Product Options: Drawings indicate size, profiles, and dimensional requirements of switchgear and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with IEEE C2.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver in sections of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation at indicated ampere ratings for the following conditions:
 - 1. Ambient temperature not exceeding 122 deg F.
 - 2. Altitude of 1,000 ft. above sea level.
- B. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager and Owner no fewer than **two weeks** in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Construction Manager's and Owner's written permission.

1.10 COORDINATION

- A. Coordinate layout and installation of switchgear and components with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.11 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: 2 sets of 3 of each type and rating used.
 2. Indicating Lights: Six of each type installed.
 3. Touchup Paint: 3 containers of paint matching enclosure finish, each 0.5 pint.
- B. Maintenance Tools: Furnish tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include the following:
1. Fuse-handling tool.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 MANUFACTURED UNITS

- A. Description: Factory assembled and tested, and complying with IEEE C37.20.1.
- B. Ratings: Suitable for application in 3-phase, 60-Hz, solidly grounded-neutral system.
- C. System Voltage: 8.32 kV nominal; 15 kV maximum.

2.3 PAD MOUNTED SWITCHGEAR

- A. Manufacturers:
1. Federal Pacific
 2. S&C
 3. Industrial Electric Mfg.
 - 4.
- B. General
1. Plans
 - a. The padmounted gear shall be in accordance with the applicable plans, drawings and one-line diagrams and shall conform to these specifications.
 2. Assembly:
 - a. The outdoor padmounted gear shall consist of a single self-supporting enclosure, containing three-phase gang-operated interrupter switches and three-phase sets of single-pole fuses with the necessary accessory components, all completely factory assembled and operationally checked.

3. Coordination:
 - a. To ensure a completely coordinated design, the padmounted gear shall be integrally designed and produced by the manufacturer of the basic switching equipment.
4. Certification of Ratings:
 - a. The manufacturer shall be completely and solely responsible for the performance of the basic switch and fuse components as well as the complete integrated padmounted gear assembly as rated.
 - b. The manufacturer shall furnish, upon request, certification of ratings of the basic switch and fuse components and/or the integrated padmounted gear assembly consisting of the switch and fuse components in combination with the enclosure. This certification of the integrated unit shall include testing the padmounted gear to the fault close requirements of the specification to assure the bus support system and components are adequate.
5. Submittals:
 - a. The manufacturer shall furnish the following drawings and reports:
 - 1) Layout showing dimensions, arrangements, electrical ratings, components and weights.
 - 2) Certified test reports of similar manufactured units showing fault closing capability and load interrupting capability of switches and complete padmounted gear assembly based on maximum design voltage.
6. Compliance with Standards & Codes:
 - a. The pad-mounted switchgear shall conform to or exceed the applicable requirements of the following standards and codes:
 - 1) All portions of ANSI C57.12.28, covering enclosure integrity for pad-mounted equipment.
 - 2) Article 100-II in the National Electrical Code, which specifies that the interrupter switches in combination with power fuses shall safely withstand the effects of closing, carrying, and interrupting all possible currents up to the assigned maximum short-circuit rating.
 - 3) All portions of IEEE C37.73 and C37.74, and all portions of ANSI C37.72 covering switch testing.
 - 4) All portions of ANSI, IEEE, and NEMA standards applicable to the basic switch and fuse components.
7. Enclosure Design:
 - a. To ensure a completely coordinated design, the padmounted gear shall be constructed in accordance with the minimum construction specifications of the fuse and/or switch manufacturer to provide adequate electrical clearances and adequate space for fuse handling.
 - b. In establishing the requirements for the enclosure design, consideration shall be given to all relevant factors such as controlled access and tamper resistance.
8. Ratings:
 - a. Ratings for the integrated padmounted assembly shall be as designated below

b. System Voltage Class		
e. kV, Nominal		
h. kV, Maximum Design		
k. kV, BIL		

n.	Main Bus Continuous, Amps		
q.	Switch Load-Interrupting, Amps		
t.	Switch Fuse Load-Interrupting, Amps		
w.	Switch Short-Circuit Ratings*		
x.	Amps, RMS Symmetrical	y.	Standard
		bb.	HFC
ee.	Peak Withstand Current, Amperes	ff.	Standard
		ii.	HFC
ll.	MVA, 3-Phase Symmetrical at Rated Nominal Voltage	mm.	Standard
		pp.	HFC
ss.	Fault-Closing Amps, RMS, Asym., 3-Time Duty-Cycle	tt.	Standard
		ww.	HFC

* These are nominal switch ratings. Integrated padmounted unit may be limited by the fuse, bushing wells, bushing inserts, elbow and cable ratings used with these units. Most 200 ampere elbow and insert systems are limited to 10,000 amperes rms sym (1.3 max. asym. factor). Use fuse rating chart and elbow limitations to select proper overall short circuit ratings.

** The three-time duty-cycle fault closing rating means that the switch can be closed three times into rated fault current and remain operable and able to carry and interrupt its rated load current.

C.

1.	Fuse Ratings		
2.	Fuse Manufacturer	3.	Fuse Type
		4.	Three-Phase MVA Sym.
7.	14.4 kV Nominal Voltage		
8.	S&C	9.	SM-4
		10.	310
13.	S&C	14.	SMU-20
		15.	350
18.	Cutler-Hammer	19.	DBU
		20.	350
23.	Cooper(M-E)	24.	NX
		25.	620
28.	25 kV Nominal		
29.	S&C	30.	SM-4†
		31.	540
34.	S&C	35.	SMU-20
		36.	540

39. Cutler-Hammer	40. DBU	41. 540
44. Cooper(M-E)	45. NX	46. 1080

** 100 amp @ 13.5KV max. or 80 amp @ 15.5KV.

†Applicable to solidly grounded neutral systems only with fuses connected by a single conductor concentric neutral type cable to a transformer or transformers. Rating is 9,400 amperes RMS symmetrical, 15,000 amperes RMS asymmetrical, 405 MVA symmetrical for all other applications.

49.

50. Insulators

a. The interrupter switch and fuse mounting insulators shall have the following material characteristics and restrictions:

- 1) Operating experience of at least 15 years under similar conditions.
- 2) Ablative action to ensure non-tracking properties.
- 3) Adequate leakage distance established by test per IEC Standard 60507.
- 4) Adequate strength for short-circuit stress established by test.
- 5) Conformance with applicable ANSI standards.
- 6) Homogeneity of the cycloaliphatic epoxy resin throughout each insulator to provide maximum resistance to power arcs. Ablation due to high temperature from power arcs shall continuously expose more material of the same composition and properties so that no change in mechanical or electrical characteristics takes place because of arc-induced ablation. Furthermore, any surface damage to insulators during installation or maintenance of the padmounted gear shall expose material of the same composition and properties so that insulators with minor surface damage need not be replaced.
- 7) Each insulator shall be x-rayed to assure it is essentially void free. An alternate testing method may be used only by approval of the engineer.

51. High Voltage Bus:

- a. Bus and interconnections shall consist of bare aluminum bar of 56% IACS conductivity with an oxide-inhibiting agent at all bus joints.
- b. Bus and interconnections shall withstand the stresses associated with short circuits up through the maximum rating of the padmounted gear, including proper allowance for transient conditions.
- c. Bolted aluminum-to-aluminum connections shall be made with a suitable number of non-corrosive bolts and with two Belleville spring washers per bolt, one under the bolt head and one under the nut. Bolts shall be tightened to an appropriate torque to assure good electrical connection.

52. Ground Connection Pads:

- a. A ground connection pad shall be provided in each termination compartment of the padmounted gear.
- b. The ground connection pad shall be constructed of 1/4" thick, galvanized or stainless steel and have a NEMA 2-hole pattern for ground connections. The pad shall be welded to the enclosure and shall have a short-circuit rating equal to that of the integrated assembly.
- c. A full width copper grounding rod shall be provided in each cable terminating compartment.

D. Construction

1. Enclosure:
 - a. The padmounted enclosure shall be of unitized construction (not structural frame and bolted sheet) to maximize strength, minimize weight, and inhibit internal corrosion.
 - b. The basic materials shall be 11 gauge hot rolled, pickled and oiled steel sheet. All structural joints and butt joints shall be welded, and the external seams shall be ground flush and smooth. A welding process shall be employed that eliminates alkaline residues and minimizes distortion and spatter.
 - c. To guard against unauthorized or inadvertent entry, enclosure construction shall not utilize any externally accessible hardware.
 - d. The base shall consist of continuous 90-degree flanges, turned inward and welded at the corners, for bolting to the concrete pad.
 - e. The door openings shall have 90-degree flanges, facing outward, that shall provide strength and rigidity as well as deep overlapping between doors and door openings to guard against water entry.
 - f. In consideration of tamper resistance, the enclosure shall conform to or exceed the requirements of ANSI C57.12.28.
 - g. A heavy coat of insulating "no-drip" compound shall be applied to the inside surface of the roof to reduce condensation of moisture thereon.
 - h. Lifting tabs shall be removable. Sockets for the lifting tab bolts shall be blind-tapped. A protective material shall be placed between the lifting tabs and the enclosure to prevent the tabs from scratching the enclosure finish. This material shall be non-hygroscopic to prevent moisture from being absorbed.
 - i. A steel (compartmented) base spacer shall be provided to increase the elevation of live parts in the padmounted gear above the mounting pad by 6 inches.
2. Barrier Assembly:
 - a. Insulating interphase and end barriers shall be provided in each switch and fuse compartment. This barrier system shall be constructed of fiberglass reinforced polyester (NEMA rated GPO-3).
3. Doors:
 - a. Doors shall be constructed of 11 gauge hot rolled, pickled and oiled steel sheet.
 - b. Door edge flanges shall overlap with door opening flanges and shall be formed to create a mechanical maze that shall guard against water entry or discourage tampering or insertion of foreign objects.
 - c. Doors shall have a minimum of three stainless steel hinges and hinge pins. The hinge pins shall be secured in place to guard against tampering.
 - d. One active and one passive door shall be provided and in consideration of controlled access and tamper resistance, each active door shall be equipped with a positive-action three-point auto-latch mechanism and padlock hasp.
 - e. Each active door shall be provided with a stainless steel door handle. The door handles shall be padlockable and shall incorporate a hood to protect the padlock shackle from tampering and access to the operating bolt. Each handle shall be provided with a recessed penta (hex optional) head bolt for additional security.
 - f. Each passive door shall be independently secured to the enclosure and shall not require a tool for opening.
 - g. Doors providing access to fuses shall have provisions to store spare expulsion type fuse units or refills.

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- f. Circuit interruption shall be accomplished by use of an interrupter which is positively and inherently sequenced with the blade position. It shall not be possible for the blade and interrupter to get out of sequence.
 - g. Interrupter switches shall have a readily visible open gap when in the open position to allow positive verification of correct switch position. In addition, an open/close label shall be provided to give a visual indicator of switch position.
 - h. Each interrupter switch shall be provided with a switch operating handle. The switch-operating handle shall be secured to the inside of the switch operating hub pocket and shall be stored behind the switch operating hub access door.
 - i. Provision to padlock switch operating hub in open or closed position shall be provided.
 - j. Cable guides shall be provided to help orient cables at switch and bus compartment terminals.
 - k. Mounting provisions shall be provided to accommodate one three-phase fault indicator with three single-phase sensors in each switch compartment (except series tap switch, where furnished).
6. Switch Compartments:
- a. Switch terminals shall be equipped with 600 ampere rated bushings that include removable threaded studs to accommodate a choice of termination systems. Fuse terminals are equipped with 200 ampere rated bushing wells designed to accept 200 ampere bushing inserts. Bushings and bushing wells have interfaces in accordance with ANSI/IEEE Standard 386 (ANSI Standard C119.2) to accept all standard separable insulated connectors and inserts. Parking stands are provided adjacent to each bushing and bushing well to accommodate feed-throughs and standoff insulators.
 - b. All medium-voltage switch and fuse components are completely encased in an inner grounded steel compartment. The component compartment floor shall be of 18-gauge galvanized steel sheet to exclude foliage and animals.
 - c. Viewing windows are provided within the termination compartments to allow visual verification of switch position, observation of switch-position open/close labels and inspection of blown-fuse indicators on power fuses.
7. Fuse Compartment:
- a. Fuse access panels have a mechanical interlock that guards against gaining access to the fuse before opening the loadbreak separable insulated connector at the fuse terminal.
 - b. The fuse shall be accessible only when de-energized and isolated — for full-view non-loadbreak disconnection and removal with a shotgun stick. This mounting features positive latching in both the energized and de-energized positions. When latched in the open position, the de-energized fuse is electrically isolated and readily accessible to operating personnel for removal.
 - c. Access to the compartment containing energized switches or fuses shall be blocked by a latched GPO-3 panel.
 - d. Individual ground rings are provided for each fuse mounting to allow convenient grounding of cable concentric neutrals and elbow accessories. These ground rings are also equipped with cable guides to assist in cable training and to prevent cables from interfering with movement of the fuse-access panel.
 - e. To provide maximum service life and to prevent corrosion of moving parts, all latches and pivots in the fuse-handling mechanism are either painted steel, stainless steel, or zinc-plated.
 - f. Fuse storage hooks shall be provided on fuse-termination compartment access door(s). Each set of hooks shall allow the storing of three spare fuseholder or fuse units with end

fittings for power fuses. Storage hooks shall be for two holders when current limiting fuses are used.

E. Labeling:

1. Warning Signs:
 - a. All external doors shall be provided with NEMA approved "WARNING — HIGH VOLTAGE — KEEP OUT" signs.
2. Rating Nameplates & Connection Diagrams:
 - a. The outside of both the front and back shall be provided with nameplates indicating the manufacturer's name, catalog number, model number, and date of manufacture.
 - b. The inside of each door shall be provided with a ratings label indicating the following: voltage ratings; main bus continuous rating; short-circuit ratings (amperes, RMS symmetrical and MVA three-phase symmetrical at rated nominal voltage); the type of fuse and its ratings including duty-cycle fault-closing capability; and interrupter switch ratings, including duty-cycle fault closing capability and amperes, short-time, RMS (momentary asymmetrical and one-second symmetrical).
 - c. A three-line connection diagram showing interrupter switches, fuses and bus along with the manufacturer's model number shall be provided on the inside of both the front and rear doors, and on the inside of each switch operating hub access cover.
 - d. Refer to drawing details for engraved equipment labels to be provided.

F. Auxiliaries:

1. End fittings or holders, and fuse units or refill units for original installation, as well as spare fuse unit or refill unit for each fuse mounting, shall be furnished in accordance with the client's requirements when specified.

G.

2.4 PAD MOUNTED VACUUM FAULT INTERRUPTER (VFI) SWITCHGEAR

A. Manufacturers:

1. Eaton / Cooper

B. General

1. The unit is to be insulated with E200 less-flammable fluid for operation to -30 degrees C contained in a sealed tank design, so operation is unimpaired by flood conditions or contaminated environments (except control). The unit shall utilize vacuum interrupters for all current switching and fault current interruption such that the dielectric media is not consumed or contaminated by normal operations of the interrupters. The unit shall be designed for installation on a concrete or fiberglass pad at ground level.
2. The switchgear shall use resettable interrupter controls and shall not rely on fuses for overcurrent protection.

C. Applicable Standards

1. IEEE Std C37.74™-2003 standard – IEEE Standard Requirements for Subsurface, Vault, and Pad-Mounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems Up to 38 kV
2. IEEE Std C57.12.28™-2005 standard – Standard for Pad-Mounted Equipment - Enclosure Integrity.
3. IEEE Std 386™-2006 standard – Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.
4. IEEE Std C37.90™-2005 standard – IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
5. IEEE Std C37.90.2™-2004 standard – Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

D. Ratings, The switchgear shall be rated* as follows:

E.

1. Nominal Voltage	2. 15kV
7. Maximum Design Voltage, kV	8. 15
12. BIL, kV	13. 95
17. 1 Minute Withstand Voltage (60Hz), kV	18. 35
22. Momentary Current, 10 Cycles (sym.), kA	23. 12.5

27.	3-second Withstand Current (sym.), kA			28.	12.5	
32.	Fault Interrupter	33.	Continuous (max), A	Current,	34.	600
		38.	Interrupting (sym./asym.)	Current	39.	12.5/20.0
		43.	Making Current (sym.), kA		44.	12.5
		48.	Cable Charging Interrupting Current, A		49.	10
53.	Load Break Switch	54.	Continuous (max), A	Current,	55.	600
		59.	Load Switching, A		60.	600
		64.	Fault Making, kA (sym./asym.)		65.	12.5/20.0
69.	Minimum Full Life Fault Interrupting Duty Cycle				71.	Number of Operations
70.	per IEEE Std C37.60™-2003 standard (2 duty cycles) Number of Operations					
72.	Percent of Interrupting Current Rating:	73.	15-20%		74.	88
		78.	45-55%		79.	112
		83.	90-100%		84.	32
88.	Total				89.	232

93. *Continuous and short-circuit currents may be limited by ratings of selected bushings.

94. *When Envirotemp™ FR3™ is used operating temperature is 0 °C to +40 °C

F. Construction

- The underground distribution switchgear shall consist of a 2-sided, sealed insulation tank, and separate front and rear cable compartments. Overall height, width, depth and layout shall conform to the manufacturer's standard construction practices for the configuration, ratings, and voltage class specified. Standard construction shall be of select: mild steel with stainless steel hardware or 100% 304L stainless steel.
- [select: The liquid filled unit shall have a tamperproof bolted tank cover design, utilizing Buna-N rubber gaskets, or the SF6 filled tank shall be of welded construction with a welded cover]. The sealed tank (with deadfront terminators installed) shall be capable of withstanding flood immersion while energized, and shall be impervious to contaminants and animals, so as not to compromise the main insulation structure. The cable compartments shall be located at the front and back of the

- tank respectively. The main cable compartments may house a combination of source way(s) and load or tap way(s). All switch and VFI operating handles shall be located on the same front plate as the ways that they operate, in order to reduce the likelihood of operating an incorrect switch. Recessed lifting provisions for suitable balanced lift shall be provided on the tank ends.
3. Cable compartments shall both have a minimum depth of [16, inches], to provide ease of cable installation and allow for the addition of termination accessories.
 4. Side-hinged cabinet style doors shall be provided. The side-hinged doors shall provide three-point latching and shall not require a center support post. Side-hinged doors shall have a door stay to manually latch the door in the open position at approximately 120° from the closed position. The right hand door on each side shall be the first opening door and shall be secured with a recessed stainless steel pentahead bolt, with provisions for padlocking. The cabinets shall be equipped with a hinged cabinet top to facilitate entry to the cable compartments; it shall open approximately 60 degrees and have door stays to hold it in the open position. The cabinet top when in the closed position shall interlock with the cabinet doors without additional means required to secure it. Cabinet construction shall meet all NEMA and ANSI security requirements defined in the IEEE Std C57.12.28™-2005 standard, and the construction requirements of the IEEE Std C37.74™-2003 standard.
 5. Units shall be shipped complete with E200 less-flammable fluid for operation to -30 degrees C.
 - a. The unit shall be equipped with a 1-inch oil-fill plug and a 1-inch drain plug with 3/8" sampler. A single automatic pressure relief valve shall be supplied that is hotstick-operable and located on the source-side front plate above the oil level indicator within the switchgear. The unit shall have sight gages to monitor the dielectric level located on each unit side equipped with an operating handle.
 6. A 1/2-13 UNC stainless steel ground nut shall be provided that is welded to the switchgear tank and mounted beneath each way. The manufacturer shall provide a factory assembled 1/2-inch diameter copper ground rod in each compartment, for use with user's grounded clamps, that shall provide a 3 inch clearance from the ground rod to the front plate of the tank to accommodate grounding of the insulated connectors.
 7. A non-corrosive operating diagram (one-line schematic of the unit) shall be affixed to the inside of the right hand, first opening door, on both sides of the unit, if two (2) sided. When visible break switches are specified (liquid insulation only), the one-line schematic will also show the electrical connection and mechanical interlock of these switches. A single nameplate shall be provided that is mounted on the source side tank front plate in the upper right hand corner. The nameplate shall contain the following information:
 - a. Catalog Number/Model Number
 - b. Serial Number
 - c. Nominal voltage class, kV
 - d. Rated maximum voltage, kV
 - e. BIL, kV
 - f. Manufacturing Date: MM/YYYY
 - g. Rated continuous current, A
 - h. Rated load interrupting rating, A
 - i. Momentary current rating, kA asym.
 - j. Close & latch rating, kA asym.
 - k. Total weight, lbs.
 - l. Liquid dielectric volume (gallons)
 8. Three (3) Faulted Circuit Indicator mounting provisions shall be provided in the sills beneath the cabinet doors at the position of each way. The provisions shall include a 1-1/16 diameter hole sized for a Cooper Power Systems S.T.A.R. fault indicator small remote display, cover plate, and

tamperproof mounting in a 4-bolt pattern. There shall be provisions for mounting at least one fault indicator for each equipment bushing.

9. Bushings

- a. Bushings shall be deadfront type for use with separable connectors conforming to IEEE Std 386™-2006 standard and ANSI Standard C119.2. The source ways shall have a continuous current rating of 600 ampere with bushings. Tap ways shall have a continuous current rating of 600 ampere with bushings.
- b. Six hundred (600) ampere bushings shall be horizontally configured at 24 inches above the pad and accept molded, separable deadfront connectors. Bushings shall be mounted with minimum spacing of 8.0-inches between centerlines, except between the C-phase bushings which may be a minimum of 7.0-inches. A standoff bracket or parking stand shall be supplied for each bushing and shall be mounted horizontally adjacent to each bushing on a 4.0-inch centerline from the bushing centerline. The standard phasing of the bushings from left to right shall follow the sequence ABC-CBA. Each bushing shall have identification affixed to the front plate identifying its source or tap designation, as shown on the one-line operating diagram, and its phase identification.
- c. Where 35 kV rated switchgear with 200-amp sources or taps are specified, Cooper Power Systems one-piece, loadbreak, large interface, integral bushings shall be supplied.
- d. Bushings and bushing wells shall be externally replaceable and shall not require removal of the tank cover or welding to remove or install replacements.

10. Source Switches

- a. Source Switches shall utilize vacuum interruption only, such that the dielectric media is never contaminated by switching arc products. Switches shall be three-phase gang-operated vacuum switches that meet or exceed the performance requirements of IEEE Std C37.74™-2003 standard. The mechanism and the vacuum interrupters employed shall be capable of interrupting the rated continuous current 200 amperes. The switch shall have a single operating handle, designed for operation with a lineman's hotstick, which has a push to close / pull to open operation. Operation of the handle shall requiring no more than 75 lbs. of force and 60 degrees of movement for complete operation. The mechanism shall close the switch independently of the operator's speed of moving the handle. The switch, as a safety feature, shall close into a fault and remain closed at any current up to its full rating. Switch operating handles shall be front plate mounted and shall be padlockable in both the open and closed positions.

11. Vacuum Fault Interrupters

- a. The switchgear shall incorporate vacuum fault interrupters for tap overcurrent protection only, such that the major dielectric media is never contaminated by circuit interruption arc products. The device shall be capable of interrupting all fault currents up to its maximum rated current of (see table in Section 3): **16,000** RMS amperes symmetrical. The interrupter shall be manually resettable, with no consumable parts (i.e. fuses). The maximum interrupting time from issuance of a trip signal from the electronic control shall be 2 cycles.
- b. To maximize safety to the operator, the interrupter shall incorporate a trip-free mechanism to prevent the possibility of holding the interrupter mechanism closed under a faulted circuit condition.
- c. The vacuum fault interrupters shall act as a three-phase group operated fault interrupter. The trip mechanisms for each phase shall be mechanically linked and the electronic control shall be set so that an overcurrent condition on any one phase shall simultaneously trip all three phases. A single operating handle shall be provided for manual opening, reset and closing. The operating handle(s) shall be mounted on the front plate of the tank in close relation to the VFI being controlled and shall have three distinct operating positions

corresponding to the vacuum fault interrupter positions of closed, open, or tripped. A pointer attached to the handle shall be provided for ready identification of the handle's position. The handle shall be designed for operation with a lineman's hotstick and have a push to close / pull to open / pull to reset operation requiring no more than 75 lbs. of force and 60 degrees of movement for complete operation. Except when equipped with the optional motor operator, when the vacuum fault interrupter is tripped by automatic action of the VFI control, the operating handle shall drop to an intermediate position between its closed and open positions, to provide indication that it is tripped. When optional motor operators are used or provisions for future motor operators are specified, semaphores are required to display the open-close status of the interrupter or switch contacts. The operating handle assembly shall include provisions to padlock the handle in the open position.

- G. Visible Break Switch (600A or less liquid filled units only)
 - a. A separate, interlocked, visible break switch shall be provided in each circuit. This shall be available on the source switches, and/or, the VFI load protecting interrupters. The visible break switch shall be 3 position (Open/Closed/Cable Ground). The visible break option will consist of an isolating switch, in series with the vacuum switch, which meets all of the continuous current and voltage ratings of the switchgear. The contacts of the visible break switch will be clearly visible through a 4" x 11" view window manufactured of a clear material with an impact strength rating of "Excellent". Both the vacuum switches or interrupters and their corresponding visible break switches shall be mechanically interlocked such that the visible break switch will never operate under load. All current interruption shall be by the vacuum interrupters. For 4-way units, the visible break switches shall be operated from the side of the switchgear via a rotary style hot stick operable handle. The operating handles for optional visible break switches shall be located at the sides of the switchgear tank inside padlockable "side-pockets". These "side pockets" shall be bolted shut using pentahead bolts and shall house T-Handles for operation of the rotary style visible break switch handles. On 5 (five) and 6 (six) way units the center switches may be front-operable.
- H. Finish Performance Requirements:
 - 1. The switchgear shall be constructed of mild steel with stainless steel details and painted green conforming to Munsell 7GY 3.29/1.5 unless otherwise specified. The coating system employed shall meet or exceed IEEE Std C57.12.28™-2005 standard coating system requirements for underground distribution equipment, including the following performance tests:
 - a. 1500-hour 5% salt spray corrosion test per ASTM B117 / D1654
 - b. 1000-hour humidity test per ASTM D2247 / D1654
 - c. 500-hour ultraviolet accelerated weathering test per ASTM G53 / D523
 - d. Direct impact test with 160 in. lb. falling dart per ASTM D2794
 - e. Tabor abrasion test 3,000 cycles per ASTM D4060
 - f. Crosshatch adhesion per ASTM D3359

2.5 METAL ENCLOSED SWITCHGEAR

- A. Manufacturers:
 - 1. Eaton / Cooper
- B. Comply with IEEE C37.20.3.

- C. Design Level of Available-Source Fault Current: Integrated short-circuit rating consistent with value of fault current indicated.
- D. Ratings: Comply with standard ratings designated in IEEE C37.20.3 for maximum-rated voltage specified.
 - 1. Main-Bus Rating: 600 A, continuous.
- E. Interrupter Switches: Stationary, gang operated, and suitable for application at maximum short-circuit rating of integrated switchgear assembly.
 - 1. Rating: 600 -A continuous duty and load break.
 - 2. Duty-Cycle, Fault Closing: 22,400 outdoor padmounted; 40,000 indoor asymmetrical A.
 - 3. Switch Action: No external arc and no significant quantities of ionized gas released into the enclosure.
 - 4. Switch Construction: Supported entirely by interior framework of structure, with copper switchblades and stored-energy operating mechanism.
 - 5. Phase Barriers: Full length of switchblades and fuses for each pole; designed for easy removal; allow visual inspection of switch components if barrier is in place.
 - 6. Protective Shields: Cover live components and terminals.
 - 7. Fuses: De-energized if switch is open.
- F. Mechanical Interlock: Prevent opening switch compartment door unless switchblades are open, and prevent closing switch if door is open.
- G. Window: Permit viewing switchblade positions if door is closed.
- H. Power Fuses: Comply with the following and with applicable requirements in NEMA SG 2:
 - 1. Indicator: Integral with each fuse to indicate when it has blown.
 - 2. Mounting: Positively held in position with provision for easy removal and replacement from front without special tools.
 - 3. Current-Limiting Fuses: Full-range, fast-replaceable, current-limiting type that will operate without explosive noise or expulsion of gas, vapor, or foreign matter from tube.
 - 4. Expulsion Fuses: Furnished in disconnect-type mountings and renewable with replacement fuse units. Gases emitted on interruption are controlled and silenced by chambers designed for that purpose.

2.6 FABRICATION

- A. Outdoor Enclosure: Galvanized steel, weatherproof construction; integral structural-steel base frame with factory-applied asphaltic undercoating.
 - 1. Low profile design: Height of unit shall not exceed 48 inches.
 - 2. Each compartment shall have the following features:
 - a. Structural design and anchorage adequate to resist loads imposed by 125-mph wind.
 - b. Louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.
 - c. Hinged front door with locking provisions.

- B. Finish: Manufacturer's standard gray finish over rust-inhibiting primer on phosphatizing-treated metal surfaces.
- C. Bus Transition Unit: Arranged to suit bus and adjacent units.
- D. Incoming-Line Unit: Arranged to suit incoming line.
- E. Outgoing Feeder Units: Arranged to suit distribution feeders.
- F. Key Interlocks: Arranged to effect interlocking schemes indicated.
- G. Provisions for Future Key Interlocks: Mountings and hardware required for future installation of locks, where indicated.

2.7 COMPONENTS

- A. Main Bus: Copper, silver plated at connection points; full length of switchgear.
- B. Ground Bus: Copper, tin plated; minimum size 1/4 by 2 inches; full length of switchgear.
- C. Bus Insulation: Covered with flame-retardant insulation.
- D. Instrument Transformers: Comply with IEEE C57.13.
 - 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - 2. Current Transformers: Burden and accuracy class suitable for connected relays, meters, and instruments.
- E. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems, listed and labeled by an NRTL, and with the following features:
 - 1. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
 - 2. Switch-selectable digital display with the following features:
 - a. Phase Currents, Each Phase: Plus or minus 1 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
 - d. Three-Phase Real Power: Plus or minus 2 percent.
 - e. Three-Phase Reactive Power: Plus or minus 2 percent.
 - f. Power Factor: Plus or minus 2 percent.
 - g. Frequency: Plus or minus 0.5 percent.
 - h. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
 - i. Accumulated energy, in megawatt hours, plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
 - 3. Communications module suitable for remote monitoring of meter quantities and functions. Interface communication and metering requirements according to Division 26 Section "Electrical Power Monitoring and Control."
 - 4. Mounting: Display and control unit that is flush or semiflush mounted in instrument compartment door.

- F. Relays: Comply with IEEE C37.90, integrated digital type; with test blocks and plugs.
- G. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with NEMA LA 1.
 - 1. Install in cable termination compartments in each phase of source circuit.
 - 2. Coordinate rating with circuit voltage.
- H. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
- I. Control Power Supply: DC battery system.
- J. Control Power Supply: Control power transformer supplies 120-V control circuits through secondary disconnect devices. Include the following features:
 - 1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
 - 2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
 - a. Secondary windings connected through relay(s) to control bus to affect an automatic transfer scheme.
 - b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
 - 3. Control Power Fuses: Primary and secondary fuses provide current-limiting and overload protection.
- K. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
 - 1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
 - 2. Conductors sized according to NFPA 70 for duty required.

2.8 DEADFRONT SECTIONALIZING CABINET:

- A. Manufacturers:
 - 1. Eaton / Cooper
- B. Scope
 - 1. This specification covers test and mechanical characteristics of single-phase and three-phase sectionalizing enclosures.
- C. UL Listing
 - 1. Obtain UL listing for all sectionalizing cabinets. Provide third party listing as required to obtain listing.
- D. Applicable Standards

1. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following standards
2. IEEE Std C57.12.28™-2014 standard - IEEE Standard for Pad-Mounted Equipment - Enclosure Integrity
3. IEEE Std C57.12.38™-2014 standard - IEEE Standard for Pad-Mounted-Type, Self-Cooled, Single-Phase Distribution (Parking Stands Only).
4. IEEE Std 386™-2006 standard - IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V.

E. Construction

1. The sectionalizing enclosure must be continuous seam-welded and manufactured of 12-gauge HRPO mild steel.
2. Enclosures must also be available in stainless steel and aluminum for high corrosive areas.
3. All hardware must be stainless steel for corrosion resistance.
4. Enclosure must be available in the colors shown below and meet the finish requirements as defined in IEEE Std. C57.12.28™-2014 standard.
 - a. Munsell Green color 7GY 3.29-1.5 (standard)
 - b. ANSI Grey 70
 - c. Desert Tan FS-595B-33446
 - d. Eagle Feather Tan FS-595-23578
 - e. Tobacco Brown FS-595C-30108
5. Enclosure must include a top hinged removable cover and allow one person operation. Cover must also include a wind stop to prevent accidental closing.
6. Enclosure must include a deep angled recessed door with low sill for easy accessibility.
7. Enclosure must include universal mounting plates painted light grey for optimum visibility of cable terminations and must accept the following:
 - a. 200 A, 15, 25 & 35 kV, two-, three- and four-position loadbreak junctions (enclosure size dependent).
 - b. 600 A, 15/25 & 35 kV, two-, three- and four-position deadbreak junctions (enclosure size dependent).
 - c. 600 A, 15, 25, & 28 kV Class loadbreak connector system (square configuration (enclosure size dependent)).
8. Enclosures must be available with junctions installed.
9. Enclosure must include "parking lot" parking stand design providing multiple options for parking of accessories and providing rigidity to the back of the enclosure to prevent oil-canning during operation.
10. Enclosure must provide a minimum of 1 parking stand pocket per phase.
11. Enclosure must include a minimum of one grounding provision per phase.
12. Enclosure must include provisions for lifting.
13. Enclosure must include a recessed lock pocket, padlock hasp and pentahead bolt for security.

F. Dimensions

1. Enclosures must be available in the following sizes:
 - a. 30"H X 66"W X 22"D

G. Optional Features

1. Fiberglass ground sleeves to accommodate enclosures must be available in 18" and 30" heights.

2.9 IDENTIFICATION

- A. Materials: Refer to Division 26 Section "Identification for Electrical Systems." Identify units, devices, controls, and wiring.

2.10 SOURCE QUALITY CONTROL

- A. Before shipment of equipment, perform the following tests and prepare test reports:
 1. Production tests on completed switchgear assembly according to IEEE C37.20.2.
- B. Assemble switchgear and equipment in manufacturer's plant and perform the following:
 1. Functional tests of all relays, instruments, meters, and control devices by application of secondary three-phase voltage to voltage circuits and injection of current in current transformer secondary circuits.
 2. Functional test of all control and trip circuits. Connect test devices into circuits to simulate operation of controlled remote equipment such as circuit-breaker trip coils, close coils, and auxiliary contacts. Test proper operation of relay targets.
- C. Prepare equipment for shipment.
 1. Provide suitable crating, blocking, and supports so equipment will withstand expected domestic shipping and handling shocks and vibration.
 2. Weatherproof equipment for shipment. Close connection openings to prevent entrance of foreign material during shipment and storage.

2.11 FACTORY FINISHES

- A. Finish: Manufacturer's standard color finish applied to equipment before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance.
 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Anchor switchgear assembly to 4-inch, channel-iron sill embedded in **[concrete base]** and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into concrete base.
2. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no less than 3 inches in all directions beyond the maximum dimensions of switchgear, unless otherwise indicated or unless required for seismic anchor support.

- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchgear units and components.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems." Refer to plans for additional identification and labelling requirements.

- B. Diagram and Instructions:

1. Frame under clear acrylic plastic on front of switchgear.
 - a. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
 - b. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
2. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

3.4 CONNECTIONS

- A. Cable terminations at switchgear are specified in Division 26 Section "Medium-Voltage Cables."
- B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables" and Division 26 Section "Medium-Voltage Cables."

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect switchgear, wiring, components, connections, and equipment installation. Test and adjust components and equipment.

2. Assist in field testing of equipment.
 3. Report results in writing.
- C. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
- D. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
 - a. Switchgear.
 - b. Protective relays.
 - c. Instrument transformers.
 - d. Metering and instrumentation.
 - e. Ground-fault systems.
 - f. Battery systems.
 - g. Surge arresters.
- E. Remove and replace malfunctioning units and retest as specified above.
- F. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of switchgear. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair damaged finishes.

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear. Refer to Division 01 Section "Demonstration and Training."

PROJECT NO. 21237.20
HAVERHILL ELEMENTARY SCHOOL BID PACKAGE 6 - CONSTRUCTION
PORTAGE PUBLIC SCHOOLS

MEDIUM-VOLTAGE SWITCHGEAR
26 1300 - 24
6/30/2023

END OF SECTION 026 1300

SECTION 26 2200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

- 1. Distribution transformers.

1.2 ACTION SUBMITTALS

- A. Product Data: For each product indicated.
- B. Shop Drawings: Indicate dimensions and weights.
 - 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. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
 - 3. Include diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Qualification Data: For testing agency.
- C. Field quality-control test reports.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Include dated documentation of torque values on all equipment.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.6 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Corporation; Cutler-Hammer.
 - 2. General Electric Company.
 - 3. Magnetek Power Electronics Group.
 - 4. Micron Industries Corp.
 - 5. Siemens Energy & Automation, Inc.
 - 6. Sola/Hevi-Duty.
 - 7. Square D; Schneider Electric.
 - 8. Industrial Electric Mfg.
 - 9.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices, except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Copper or Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

- A. Must be TP-1 energy efficient compliant.
- B. Must be DOE 2016 compliant.
- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, dripproof, NEMA 250, Type 2.

- E. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 115 deg C rise above 40 deg C ambient temperature.
- F. Taps for Transformers Smaller Than 3 kVA: One 5 percent tap above normal full capacity.
- G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
- H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.
- I. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
 - 1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
 - 2. Indicate value of K-factor on transformer nameplate.
- J. Wall Brackets: Manufacturer's standard brackets.
- K. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.
 - 1. Maximum acceptable sound level:
 - a. 9 KVA and less: 37dBA.
 - b. 30 to 50 KVA: 42 dBA.
 - c. 51 to 150 KVA: 47 dBA.
 - d. 151 to 300 KVA: 52 dBA.
 - e. 301 to 500 KVA: 57 dBA.
 - f. 501 to 750 KVA: 59 dBA.
 - g. 751 to 1000 KVA: 61 dBA.

2.4 CONTROL AND SIGNAL TRANSFORMERS

- A. Description: Self-cooled, two-winding dry type, rated for continuous duty, complying with NEMA ST 1, and listed and labeled as complying with UL 506.
- B. Ratings: Continuous duty. If rating is not indicated, provide at least 50 percent spare capacity above connected peak load.

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.
- B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

2.6 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification for Electrical Systems."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls and floors for suitable mounting conditions where transformers will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
- B. Install floor-mounting transformers level on concrete bases. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
- C. Install transformers larger than 75 KVA at least 12 inches away from walls or other obstructions that might prevent free air circulation through and around the transformer.
- D. Identify transformers and install warning signs according to Division 26 Section "Identification for Electrical Systems".

3.3 CONNECTIONS

- A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- B. Connect transformer units to conduit system panelboards, disconnect switches, or junction/pull boxes, using liquid-tight flexible conduit.
- C. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 5 percent. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.5 FIELD QUALITY CONTROL

- A. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.6 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
 - 1.

END OF SECTION 26 2200

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SECTION 26 2413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.2 ACTION SUBMITTALS

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

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
3. Include schematic and wiring diagrams for power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

B. Include dated documentation of torque values on all equipment.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA PB 2.
- C. Comply with NFPA 70.
- D. Comply with UL 891.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.7 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate panels to be supplied with meter with Division 26 Section "Electrical Energy Metering".

1.8 EXTRA MATERIALS

- A. Spares: For the following:
 - 1. Potential transformer fuses.
 - 2. Control power fuses.
 - 3. Fuses for fused switches.
- B. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCT

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Square D; a brand of Schneider Electric. – Preferred by the client, others may be considered

2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. ABB Inc.
4. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
5. Siemens Energy & Automation, Inc.
6. Industrial Electric Mfg.

2.2 MANUFACTURED UNITS

- A. Front-Connected, Front-Accessible Switchboard: Panel mounted main device, panel-mounted branches, and sections rear aligned.

2.3 FABRICATION AND FEATURES

- A. Enclosure Finish for Indoor Units: Factory-applied electrostatic powder coat in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- B. Barriers: Between adjacent switchboard sections.
- C. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard, if shown on Drawings.
- D. Screwed Front Panels: Allow access to circuit-breaker, metering, accessory, and blank compartments.
- E. Buses and Connections: Three phase, four wire, unless otherwise indicated. Include the following features:
 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity with feeder fused-switch/circuit-breaker line connections.
 2. Ground Bus: 1/4-by-2-inch minimum size, drawn-temper copper of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 3. Contact Surfaces of Buses: Silver plated.
 4. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 5. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
 6. Neutral Buses: 100 percent of the ampacity of the phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus is braced.
- F. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of fused switch/circuit-breaker compartment.

2.4 SPD DEVICES

- A. Panelboard enclosure shall be designed to accommodate SPD externally. SPD shall be mounted within manufacturer recommended cable distance and shall use circuit breaker closest to SPD.

- B. Refer to Division 26 Section "Surge Protection for Low-Voltage Electrical Power Circuits."

2.5 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents with 20% additional capacity, 40,000 KA minimum. Use Electronic Trip Breakers for all trip where shown on oneline with "ET".
1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic Trip Unit Circuit Breakers (ET): RMS sensing; field-replaceable rating plug; with the following field-adjustable settings: 100% Sensing, 100% Rating.
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I²t response,
 - e. Provide electronic trip breakers where indicated on Drawings.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
- B. Molded-Case Circuit-Breaker Features and Accessories: Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
 2. Application Listing: Appropriate for application; Type HACR for heating, air-conditioning, and refrigerating equipment.
 3. Ground-Fault Protection: Where indicated on Drawings and where panel is over 1000A at 480V at the service entrance. Internally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 4. Shunt Trip: Where indicated on drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
 5. Zone-Selective Interlocking: Where indicated on drawings. Integral with electronic trip unit; for interlocking ground-fault protection function.
 6. Breakers with continuous trip setting adjustable to 1200A or higher shall be provided with remote arc energy reduction for maintenance option with remote switch to be installed near door of electrical room (where indicated on Drawings). Remote switch shall not require manual change in circuit breaker or trip device settings.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.6 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
 - 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 - 2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
 - 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
- B. Multifunction Digital-Metering Monitor (where indicated on drawings):
 - 1. Provide in accordance with Division 26 Section "Electrical Energy Metering".
 - 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.7 CONTROL POWER

- A. Control Circuits: 120 V, supplied through secondary disconnecting devices from control-power transformer.
- B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
- C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.8 ACCESSORY COMPONENTS AND FEATURES

- A. Portable Test Set: To test functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
- B. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

PART 3 - EXECUTION

3.1 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.2 EXAMINATION

- A. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance.

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

3.3 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- B. Support switchboards on concrete bases, 4-inch nominal thickness.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.5 CONNECTIONS

- A. Install equipment grounding connections for switchboards with ground continuity to main electrical ground bus.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.6 FIELD QUALITY CONTROL

- A. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.7 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.8 CLEANING

- A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to properly use the switchboard mounted metering equipment. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 2413

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SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.3 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Panelboard schedules for installation in panelboards.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.
- B. Include dated documentation of torque values on all equipment.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA PB 1.
- C. Comply with NFPA 70.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

1.7 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.
- B. Prior to equipment installation, temporarily tape off distribution equipment rough-in and NEC clearance requirements in front of equipment and above equipment for other trades to observe. Label markings "ELECTRICAL CLEAR SPACE".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Panelboards, Overcurrent Protective Devices, Controllers, Contactors, and Accessories:
 - a. Square D Co. – Preferred by the client, others may be considered
 - b. Eaton Corp.; Cutler-Hammer Products.
 - c. General Electric Co.; Electrical Distribution & Control Div.
 - d. Siemens Energy & Automation, Inc.
 - e. Industrial Electric Mfg.
 - 2. TVSS Panelboards:
 - a. Current Technology, Inc.
 - b. Liebert Corporation.
 - c. Siemens.
 - d. Square D Company.
 - e. Lea International.

2.2 FABRICATION AND FEATURES

- A. Enclosures: Flush- surface- mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
- B. Cabinet heights shall not exceed the following without pre-approval:

C. (Subtract 12 inches from max cabinet height for MLO interiors)

D.

1. NQ TYPE PANELBOARD MAIN	2. NUMBER OF SPACES	3. MAX CABINET HEIGHT
4. 100A or less MB	5. 30 spaces or less	6. 44 inches
7. 225A or less MB	8. 54 spaces or less	9. 50 inches
	10. 72 spaces or less	11. 56 inches
12. 400A or less MB	13. 42 spaces or less	14. 62 inches
	15. 72 spaces or less	16. 74 inches

17. NF TYPE PANELBOARD MAIN	18. NUMBER OF SPACES	19. MAX CABINET HEIGHT
20. 125A or less MB	21. 30 spaces or less	22. 44 inches
23. 250A or less MB	24. 54 spaces or less	25. 56 inches
26. 400A or less MB	27. 42 spaces or less	28. 68 inches
	29. 66 spaces or less	30. 86 inches

E. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.

F. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

G. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

H. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

I. Breaker numbering: Provide adhesive labels with breaker numbering to be installed on each side of breakers to identify breaker number that corresponds to circuit directory.

J. Bus: Hard-drawn copper, 98 percent conductivity.

K. Main and Neutral Lugs: Mechanical type suitable for use with conductor material. Contractor is responsible for locating top or bottom feed main or lugs appropriate for top or bottom feeds.

- L. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.
- M. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.
- N. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.
- O. Isolated Equipment Ground Bus: Where indicated on Drawings. Adequate for branch-circuit equipment ground conductors; insulated from box.
- P. Extra-Capacity Neutral Bus: Where indicated on Drawings. Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- Q. Feed-through Lugs: Where indicated on Drawings. Mechanical type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
- R. Provide handle clamps on all circuit breakers feeding fire alarm system components. Handle clamps shall lock the circuit breaker in the "ON" position.

2.3 PANELBOARD SHORT-CIRCUIT RATING

- A. Fully rated to interrupt symmetrical short-circuit current available at terminals with 20% additional capacity, 10,000 KA minimum.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- B. Circuit breaker interrupting rating shall be 10,000 RMS symmetrical amperes at 120/208/240 volts; 14,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans (add 20% to rating on plans).

2.5 DISTRIBUTION PANELBOARDS

- A. Doors: Hinged, front mounted, except omit in fused-switch panelboards; secured with vault-type latch with tumbler lock; keyed alike.
- B. Main Overcurrent Protective Devices: Circuit breaker similar characteristics to branch devices indicated below.
- C. Branch overcurrent protective devices shall be one of the following:
 - 1. For Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
 - 2. For Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
 - 3. Circuit breaker interrupting rating shall be 22,000 RMS symmetrical amperes at 120/208/240 volts; 25,000 RMS symmetrical amperes at 277/480 volts unless noted otherwise on plans.

4. Fused switches.
5. For Circuit-Breakers Indicated on plans with "ET", provide electronic trip unit circuit breakers (ET) with the following settings:
 - a. RMS sensing; field-replaceable rating plug
 - b. 100% Sensing, 100% Rating for frame sizes of 400A and higher.
 - c. Instantaneous trip.
 - d. Long- and short-time pickup levels.
 - e. Long- and short-time time adjustments.
 - f. Ground-fault pickup level, time delay, and I²t response,

2.6 SPD PANELBOARDS

- A. Refer to Division 26 Section "Surge Protection for Low-Voltage Electrical Power Circuits."
- B. Panelboard enclosure shall be designed to accommodate SPD externally. SPD shall be mounted within manufacturer recommended cable distance and shall use circuit breaker closest to SPD.

2.7 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, IEEE C57.13, and the following:
 1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
 2. Current Transformers: Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kV.
- B. Multifunction Digital-Metering Monitor (where indicated on drawings):
 1. Provide in accordance with Division 26 Section "Electrical Energy Metering".
 2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

2.8 OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.
 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. Electronic Trip Unit Circuit Breakers: (Where indicated on drawings and any over 400A) RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. 100% Rated with 100% sensing.
 - b. Instantaneous trip.
 - c. Long- and short-time pickup levels.
 - d. Long- and short-time time adjustments.
 - e. Ground-fault pickup level, time delay, and I²t response.

3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and two-pole configurations with 5 mA trip sensitivity.
 5. AFCI Circuit Breakers: Single- and two-pole configurations 20A trip, evaluated to UL 1699, Safety Standard for ARC-fault Circuit Interrupter.
- B. Molded-Case Circuit-Breaker Features and Accessories. Standard frame sizes, trip ratings, and number of poles.
1. Lugs: Mechanical style, suitable for number, size, trip ratings, and material of conductors.
 2. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment; HID rated for high intensity discharge lighting.
 3. Ground-Fault Protection: Where indicated on Drawings. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 4. Main breaker over 1000A at 480V on service entrance panel shall have ground fault protection.
 5. Breakers or trip devices with continuous trip setting adjustable to 1200A or higher shall be provided with remote arc energy reduction for maintenance option with remote switch to be installed near door of electrical room (where indicated on Drawings). Remote switch shall not require manual change in circuit breaker or trip device settings.
 6. Shunt Trip: Where indicated on Drawings. 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.

2.9 CONTROLLERS

- A. Contactors in Main Bus: NEMA ICS 2, Class A, mechanically held general-purpose controller.
1. Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
 2. Control-Power Source: 120-V branch circuit.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide SWD rated circuit breakers for switching fluorescent lighting; HACR rated circuit breakers for heating, air conditioning and refrigeration equipment, and HID rated circuit breakers for high intensity discharge lighting.
- B. Install panelboards and accessories according to NEMA PB 1.1.
- C. Mounting Heights:
1. Top of box 72 inches above finished floor, unless otherwise indicated.
 2. Bottom of box to be a minimum of 16 inches above finished floor.
 3. Multi-Family Dwelling Unit Accessible Units: Mount top of panel or load center so that highest breaker in panel is at or below 48 inches above finished floor.

4.

- D. Mounting: Plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.
- E. Circuit Directory: Create a directory to indicate installed circuit loads after balancing panelboard loads. Use a computer or typewriter to create directory; handwritten directories are not acceptable. All circuit loads shall be visible without removing directory card.
- F. Distribution Panel Circuit Breaker/Switch Identification: Label each circuit breaker/switch unit with laminated-plastic nameplate mounted with corrosion-resistant screws or permanent adhesive.
- G. Install filler plates in unused spaces.
- H. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- I. Wiring in Panelboard Gutters: Arrange conductors into groups and bundle and wrap with wire ties after completing load balancing.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.
 - 1. Panel label to have white letters on a black background. Provide the panel name, voltage and panel fed from on label.
 - 2. Locate the label on the exterior of the panel door frame above the door unless otherwise indicated.
 - 3. Locate the label on the panel interior side of the door when panel is recessed and located in a finished space.
- C. Clearance Space: In electrical equipment rooms, mechanical rooms or janitor's closets, provide floor marking tape to indicate NEC required clear space in front of panelboards and distribution equipment. Provide floor label that reads "ELECTRICAL CLEAR SPACE". Provide floor tape and label in accordance with 260553, "Identification for Electrical Systems."

3.3 CONNECTIONS

- A. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- B. Where panelboards are located within 6 feet horizontally of any grounded structural building steel member, provide a bonding jumper between that steel member and the panelboard.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- B. Testing: After installing panelboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- C. Balancing Loads: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data-processing, computing, transmitting, and receiving equipment.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
- D. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.5 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

- A. On completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

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PORTAGE PUBLIC SCHOOLS

PANELBOARDS
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END OF SECTION 26 2416

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SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Wall-box motion sensors.
 - 3. Snap switches and wall-box dimmers.
 - 4. Communications outlets.
- B. See Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.2 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
- C. Sample Finishes: Provide sample coverplate / device finishes of all available to interior designer for selection and final approval of device and coverplates throughout space. Colors may vary per space and per wall material device is to be installed on. Samples for any coverplates and devices include but are not limited to outlets, lighting controllers, data and AV coverplates fire alarm devices and exit signs.
- D.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Wiring Devices:
 - a. Cooper Wiring Devices
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Mfg. Company Inc.
 - d. Pass & Seymour/Legrand; Wiring Devices Div.
2. Wiring Devices for Hazardous (Classified) Locations:
 - a. Crouse-Hinds/Cooper Industries, Inc.; Arrow Hart Wiring Devices.
 - b. EGS/Appleton Electric Company.
 - c. Killark Electric Manufacturing Co./Hubbell Incorporated.
3. Multi-outlet Assemblies:
 - a. The Wiremold Company.
4. Poke-Through, Floor Service Outlets and Telephone/Power Poles:
 - a. Hubbell Incorporated; Wiring Device-Kellems.
 - b. Pass & Seymour/Legrand; Wiring Devices Div.
 - c. Square D/Groupe Schneider NA.
 - d. Wiremold Company (The).
 - e. Steel City/Thomas and Betts / A Member of the ABB Group.

2.2 RECEPTACLES

A. Extra Heavy Duty/Industrial Grade Straight-Blade-Type Receptacles: Comply with NEMA WD 1, NEMA WD 6, and UL 498.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".
2. Use in mechanical rooms, higher abuse areas, lab areas and rough service areas.

B. Tamper Resistant, Commercial Grade Straight-Blade Receptacles: Comply with NEMA WD 1, NEMA WD 6 and UL498.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".

C. Tamper Resistant, Hospital Grade Straight-Blade Receptacles. Comply with NEMA WD 1, NEMA WD 6 and UL498.

1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".
2. Acceptable products:
 - a. Cooper 8300.
 - b. Hubbell HBL8300.
 - c. Leviton 8300.
 - d. P & S 8300.

- 3.
- 4.

- D. Tamper Resistant, GFCI Hospital Grade Straight-Blade Receptacles: Feed-through type, comply with NEMA WD 6, UL498 and UL943. Must meet UL 2003 standards for diagnostic indication of miss-wiring, increased surge immunity, improved corrosion resistance and resistance to false tripping.
1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant."
 2. Use in buildings where hospital grade receptacles are required.
- E. GFCI Specification Grade Straight-Blade Receptacles: Feed-through type, comply with NEMA WD 6, UL498 and UL943. Must meet UL 2003 standards for diagnostic indication of miss-wiring, increased surge immunity, improved corrosion resistance and resistance to false tripping.
1. NEMA 5-20R configuration, 125 volt, 20 ampere, listed as "tamper resistant".
 2. Use where indicated on drawings and breaker type GFCI protection is not provided and where access is restricted to facilities personal.
- F. Industrial Heavy-Duty Pin and Sleeve Devices: Comply with IEC 309-1.

2.3 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.4 SWITCHES

- A. Single and Multi-pole Switches: Comply with UL20.
- B. Snap Switches: 20A, 120/277 volt, AC, heavy-duty grade, quiet type.
- C. Keyed Switches: 20A, 120/277 volt, AC, heavy-duty grade, quiet type.
1. Provide two keys for each keyed switch installed on project. Turn-over keys to owner at time of Substantial Completion.
- D. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.
1. Wattage rating exceeds connected load by 30 percent minimum, except as otherwise indicated.
 2. Control: Continuously adjustable slider, toggle switch, or rotary knob; with single-pole or three-way switching to suit connections.
 3. Incandescent Lamp Dimmers: Modular, 120 V, 60 Hz with continuously adjustable rotary knob, toggle switch, or slider; single pole with soft tap or other quiet switch; EMI/RFI filter to eliminate interference; and 5-inch wire connecting leads.

2.5 DEVICE PLATES

- A. Single and combination types to match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: Smooth, high-impact thermoplastic. Color shall match device color.
 - 3. Material for Unfinished Spaces: Galvanized steel.. Color shall match wiring device color.
 - 4. Premium Finishes: Provide screwless decorator wall plates that snap to included subplate. Legrand SWP# series or approved equivalent, finish to be selected
 - 5. Provide device plates for all power and data outlets.

2.6 WET LOCATION RECEPTACLE COVERS

- A. Wet Location Receptacle Covers: Receptacles located outdoors or those indicated as weatherproof shall be equipped with covers that maintain the NEMA 3R weatherproof integrity when attachment plug caps are inserted.
 - 1. Covers shall be die cast aluminum with powder coat finish, UL listed and comply with NEC.
 - 2. Covers shall be:
 - a. Tay Mac Corporation # MX3200
 - b. Red Dot #CKSUV

2.7 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartmentation: Barrier separates power and signal compartments.
- C. Housing Material: Stamped steel suitable for concrete installation.
- D. Power Receptacle: NEMA WD 6, Configuration 5-20R, ivory finish, unless otherwise indicated.
- E. Signal Outlet: Blank cover with bushed cable opening, unless otherwise indicated.
- F. Finish Trim and Door: Hinged nylon carpet/tile insert door permitting passage of cords and cables while in closed position. Trim color selected by Architect.

2.8 POKE-THROUGH ASSEMBLIES

- A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
- B. Where exposed structure or non-accessible gyp board ceilings below, provide embedded poured in place floorbox with embedded conduit routed to junction box in nearby accessible ceiling space.
 - 1. Size: Selected to fit nominal 4 inch or 6" cored openings in floor and matched to floor thickness. Refer to floorplans for specific pokethrough devices specified.
 - 2.
 - 3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

4. Closure Plug: Arranged to close unused cored openings and reestablish fire rating of floor.
5. Wiring: Three No. 12 AWG power and ground conductors; one 75 ohm coaxial telephone/data cable; and one four-pair, 75 ohm telephone/data cable.

2.9 MULTIOUTLET ASSEMBLIES

- A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- B. Raceway Material: Metal, with manufacturer's standard finish.
- C. Wire: No. 12 AWG.

2.10 COMMUNICATIONS OUTLETS

- A. Telephone Outlet:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3560-6.
 - b. Leviton; 40649.
 3. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1 complying with Category 5e. Comply with UL 1863.
- B. Combination TV and Telephone Outlet:
 1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
 2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 3562.
 - b. Leviton; 40595.
 3. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.

2.11 TELEPHONE/POWER SERVICE POLES

- A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
 1. Poles: Nominal 2.5-inch (65 mm) square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
 2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
 3. Finishes: One of manufacturers standard finish and trim combinations, including painted and satin anodized-aluminum finishes and wood-grain-type trim.

4. Wiring: Sized for three No. 12 AWG power and ground conductors and telephone/data cable as indicated.
5. Power Receptacles: Two single, 20-A; heavy-duty, NEMA WD 6, Configuration 5-20R units.
6. Signal Outlets: Blank insert with bushed cable opening except as otherwise indicated.

2.12 WIRING DEVICE AND COVER FINISHES

A. **[Color Plastic:**

1. **Covers for Wiring Devices Connected to Normal Power System are to be selected based on final approved finishes into which the device is to be installed. Wiring devices are to match covers unless required by NFPA 70 or on emergency power system. Wiring devices connected to Emergency Power System are to be red.**
2. Covers on devices installed into CMU or drywall finishes shall generally be white, except for devices installed into wood, tile or stone wall finishes or casework. Devices installed into such materials shall be identified and coordinated with the finish and supplied with color chips for final selection by the interiors group.]

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades:
 1. Install devices and assemblies level, plumb, and secure.
 2. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 3. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 4. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 5. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtail existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
10. Provide an individual GFCI receptacle for each one shown on the drawings. Do not feed downstream receptacles on the same circuit using the protection of a GFCI receptacle.
11. Where GFCI receptacles are concealed behind either fixed or removable equipment, provide remote GFCI test device per NFPA-70 requirements.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.
2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical. Group adjacent switches under single, multigang wall plates.

I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 CONNECTIONS

- A. Connect receptacles using screw-compression wiring contacts or pigtail leads. Do not use push-in contacts.
- B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
- C. Isolated-Ground Receptacles: Connect to isolated-ground conductor routed to designated isolated equipment ground terminal of electrical system.
- D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

- A. Test wiring devices for proper polarity and ground continuity. Operate each device at least six times.
- B. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.
- C. Remove damaged and defective components.

3.5 CLEANING

- A. Internally clean devices, device outlet boxes, and enclosures. Replace stained or improperly painted wall plates or devices.

END OF SECTION 26 2726

SECTION 26 2813 - 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. Motor-control centers.
 - c. Panelboards.
 - d. Switchboards.
 - e. Enclosed controllers.
 - f. Enclosed switches.

1.2 ACTION SUBMITTALS

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

1.3 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

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. Comply with NEMA FU 1 for cartridge fuses.
- C. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate fuse rating with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Spare Fuses: Furnish two sets of each fuse type and size installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Ferraz Shawmut, Inc.
3. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

1. Type RK-1: 250 600-V, zero- to 600-A rating, 200 kAIC, time delay.
2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC , time delay.
3. Type CD: 600-V, 31- to 60-A rating, 200 kAIC , time delay.
4. Type J: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
5. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
6. Type T: 250-V, zero- to 1200-A 600-V, zero- to 800-A rating, 200 kAIC , time delay.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05 inch thick 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 fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Service Entrance: Class L, fast acting.
- B. Feeders: Class L or Class J, time delay.
- C. Motor Branch Circuits: Class RK1, time delay.
- D. Other Branch Circuits: Class RK5, time delay.
- E. Control Circuits: Class CC, time delay.

3.3 INSTALLATION

- A. Install fuses in fusible devices as indicated. Arrange fuses so fuse ratings are readable without removing fuse.
- B. Install spare fuse cabinet(s).

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block and holder.

END OF SECTION 26 2813

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SECTION 26 2923 - VARIABLE FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 SUMMARY

- A. Wiring for variable frequency controllers (VFC) that are provided by Division 23 for mechanical equipment.
- B. Refer to various Division 23 sections for controller requirements furnished with equipment.

1.2 REFERENCES

- A. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems; National Electrical Manufacturers Association; 1995.
- B. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives; National Electrical Manufacturers Association; 1993.
- C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); National Electrical Manufacturers Association; 1997.
- D. NFPA 70 - National Electrical Code; National Fire Protection Association.

1.3 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Electrical Code Compliance: Comply with applicable local electrical code requirements of the authority having jurisdiction and NEC Articles 220, 250, and 430, as applicable to installation, and construction of motor controllers.
- C. UL Compliance: Comply with applicable requirements of UL 486A and B, and UL 508, pertaining to installation of motor controllers. Provide materials which are UL-listed and labeled.
- D. NEMA Compliance: Comply with applicable requirements of NEMA Standard ICS 2, and Pub No. 250, pertaining to motor controllers and enclosures.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Provide wiring of VFC's where indicated; in accordance with equipment manufacturer's written instructions and with recognized industry practices; complying with applicable requirements of NEC, UL and NEMA standards, to ensure that products fulfill requirements.
- B. Provide the following power wiring and conduit.
 - 1. Wiring from MCC/power panel to drive.
 - 2. Wiring of line reactor and other any other accessories.
 - 3. Wiring from drive to motor (including wiring to near motor disconnect switch if included).
 - 4. The inter-wiring indicated above shall be provided by the contractor at no additional cost regardless of how the connection is shown diagrammatically on the floor plans or one-line.
- C. Provide control wiring and conduit between drive and smoke detectors or fire alarm panel. Provide any required relays for shutdown of multiple drives.
- D. Electrical Wiring: Electrical wiring and connections are specified in Division 26.
- E. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections.

END OF SECTION 26 2923

SECTION 26 3213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. Failure to consult these documents shall not relieve the Contractor of the requirements therein.

1.2 SUMMARY

- A. This Section includes packaged diesel-engine generator sets with the following features and accessories:
 - 1. Battery charger.
 - 2. Sub-base Style Day tank.
 - 3. Engine generator set.
 - 4. Muffler.
 - 5. Exhaust piping internal to set.
 - 6. Outdoor enclosure.
 - 7. Remote annunciator.
 - 8. Radiator.
 - 9. Remote stop switch.
 - 10. Starting battery.

1.3 DEFINITIONS

- A. Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.
- B. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
- C. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hertz or cycles per second.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of packaged engine generator and accessory indicated.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control test reports.

- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
- B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with ASME B15.1.
- E. Comply with NFPA 37.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110 requirements for Level 1 emergency power supply system.
- I. Comply with UL 2200.
- J. Comply with NFPA 70 requirements for monitoring of generator control wiring.
- K. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- L. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.8 PROJECT CONDITIONS

- A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: Minus 15 to plus 40 deg C.
 - 2. Relative Humidity: 0 to 95 percent.
 - 3. Altitude: Sea level to 1000 feet.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

1.10 COORDINATION

- A. Coordinate size and location of concrete bases for package engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
- B. Coordinate size and location of roof curbs, equipment supports, and roof penetrations for remote radiators. These items are specified in Section 07 7200 "Roof Accessories."

1.11 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace packaged engine generator and auxiliary components that fail in materials or workmanship within specified warranty period. The warranty shall have no deductibles.
 - 1. Warranty Period: Five years from date of Substantial Completion.
 - 2. Warranty to include: parts, labor and travel time for five years.

1.12 MAINTENANCE SERVICE

- A. Maintenance: Provide 1 year service agreement with cost for 1 year renewal. At Substantial Completion, begin 12 months' full maintenance by skilled employees of the manufacturer's designated service organization. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts and supplies as used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cummins Power Generation. – Preferred by the client, others may be considered.
 - 2. Generac Corp. – Preferred by the client, others may be considered
 - 3. Caterpillar, Inc.; Engine Div.
 - 4. Kohler Co; Generator Division.
 - 5. MTU - Detroit Diesel.

2.2 ENGINE GENERATOR SET

- A. Furnish a coordinated assembly of compatible components.
- B. Safety Standard: Comply with ASME B15.1.
- C. Nameplates: Each major system component is equipped with a conspicuous nameplate of component manufacturer. Nameplate identifies manufacturer of origin and address, and model and serial number of item.
- D. Power Output Ratings: Nominal ratings as indicated on drawings, with capacity as required to operate as a unit as evidenced by records of prototype testing.
- E. Skid: Adequate strength and rigidity to maintain alignment of mounted components without depending on a concrete foundation. Skid is free from sharp edges and corners. Lifting attachments are arranged to facilitate lifting with slings without damaging any components.

2.3 GENERATOR-SET PERFORMANCE FOR SENSITIVE LOADS

- A. Oversizing generator compared with the rated power output of the engine to meet performance requirements in paragraphs below is permissible.
 - 1. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
- B. Steady-State Voltage Operational Bandwidth: 2 percent of rated output voltage from no load to full load.
- C. Steady-State Voltage Modulation Frequency: Less than 1 Hz.
- D. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage recovers to remain within the steady-state operating band within 0.5 second.
- E. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
- F. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there are no random speed variations outside the steady-state operational band and no hunting or surging of speed.
- G. Transient Frequency Performance: Less than 2-Hz variation for a 50 percent step-load increase or decrease. Frequency recovers to remain within the steady-state operating band within three seconds.
- H. Output Waveform: At no load, harmonic content measured line to neutral does not exceed 2 percent total with no slot ripple. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50.
- I. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, the system will 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 any other generator system component.

- J. Excitation System: Performance is unaffected by voltage distortion caused by nonlinear load.
- K. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 SERVICE CONDITIONS

- A. Environmental Conditions: Engine generator system withstands the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
 - 1. Ambient Temperature: -15 to +50 degrees C..
 - 2. Altitude: Sea level to 1000 feet .

2.5 ENGINE

- A. Comply with NFPA 37.
- B. Fuel: Fuel oil, Grade DF-2.
- C. Rated Engine Speed: 1800 rpm.
- D. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm .
- E. Lubrication System: Pressurized by a positive-displacement pump driven from engine crankshaft. The following items are mounted on engine or skid:
 - 1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
 - 2. Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit is 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 or siphons or special tools or appliances.
- F. Engine Fuel System: Comply with NFPA 37. System includes the following:
 - 1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
 - 2. Relief/Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.
- G. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Heater shall be thermostatically controlled. Comply with NFPA 110 requirements for Level 1 equipment.
- H. Provide vibration isolation between generator set and concrete pad per manufacturer recommendation (typically on larger units only), not required on units with integral vibration isolation between engine and frame rail.

2.6 GOVERNOR

- A. Type: Adjustable isochronous, with speed sensing, electronic type.

2.7 ENGINE COOLING SYSTEM

- A. Description: Closed loop, liquid cooled, with radiator factory mounted on engine generator-set skid and integral engine-driven coolant pump.
- B.
- C. Radiator: Rated for specified coolant.
- D.
- E. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
- F. Expansion Tank: Constructed of welded steel plate and equipped with gage glass and petcock.
- G. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- H. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
 - 1. Rating: 50-psig maximum working pressure with 180 deg F coolant, and noncollapsible under vacuum.
 - 2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
- I. Coolant piping external to engine generator set. Refer to Division 23 Section "Hydronic Piping" for materials and installation requirements for piping.

2.8 FUEL SUPPLY SYSTEM

- A. Comply with Michigan DEQ, NFPA 30 and NFPA 37.
- B. Day Tank: Sub-base style, factory-fabricated assembly of a dual-walled fuel tank listed by a nationally recognized testing laboratory, with the following features:
 - 1. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
 - a. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
 - 2. Tank Capacity: Adequate to supply fuel to engine for an uninterrupted period of 48 hours' operation at 100 percent of rated power output of engine generator system without being refilled.
 - 3. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
 - 4. Unit, Including Alarm Contacts: Complies with UL 142.
 - 5. Low-Level Alarm Sensor: Separate device operates alarm contacts at 75 percent of normal fuel level.
 - 6. High-Level Alarm Sensor: Separate device operates alarm and redundant fuel shutoff contacts at 106 percent of normal fuel level.

7. Piping Connections: Include fuel suction and return lines to fuel storage tank; fuel supply; and return lines to engine, local fuel fill, vent line, overflow line, and tank drain line complete with shutoff valve.
8. Sub-base Day Tank shall have all options required to meet Mich DEQ Compliance.
9. Vandal-resistant fill cap in a lockable spill box.
10. Tank must be mounted on channels or have mastic coating between tank and concrete pad.

C. Interior Fuel Oil Piping: As specified in Division 23 Section "Facility Fuel-Oil Piping."

2.9 ENGINE EXHAUST SYSTEM

- A. Muffler: Critical type, sized as recommended by engine manufacturer. Muffler shall reduce exhaust noise 30 dBA or better at 500Hz.
- B. Condensate Drain for Muffler: Schedule 40, black steel pipe connected to muffler drain outlet through a petcock.
- C. Connections from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe.
- D. Connection from Exhaust Pipe to Muffler: Stainless-steel expansion joint with liners.
- E. Insulation for Mufflers and Indoor Exhaust Piping: As specified in Division 23 Section "HVAC Equipment Insulation" and Division 23 Section "HVAC Piping Insulation."
- F. Supports for Muffler and Exhaust Piping: Spring hangers and all-thread rods and vibration hangers as specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" and Division 23 Section "Hangers and Supports for HVAC Piping and Equipment"; attached to building structure.
- G. Exhaust Piping External to Engine: ASTM A 53, Schedule 40, welded, black steel, with welded joints and fittings. Refer to Division 23 Sections "Hydronic Piping" and "BREECHINGS, CHIMNEYS AND STACKS" for materials and installation requirements for piping.

2.10 COMBUSTION-AIR-INTAKE

- A. Description: Standard-duty engine-mounted air cleaner with replaceable dry filter element and "blocked filter" indicator.

2.11 STARTING SYSTEM

- A. Description: electric, with negative ground and including the following items:
 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above.
 2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
 3. Cranking Cycle: As required by NFPA 110 for system level specified.

4. Battery: Adequate capacity within ambient temperature range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above to provide specified cranking cycle at least twice without recharging.
5. Battery Cable: Size as recommended by generator set manufacturer for cable length required. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater is arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in "Environmental Conditions" Paragraph in "Service Conditions" Article above. Include accessories required to support and fasten batteries in place.
7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type with equalize charge timer. Unit complies with UL 1236 and includes the following features:
 - a. Operation: Equalizing-charging rate of 10 A is initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit then automatically switches to a lower float-charging mode and continues operating in that mode until battery is discharged again.
 - b. Automatic Temperature Compensation: Adjusts float and equalizes voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
 - c. Automatic Voltage Regulation: Maintains output voltage constant regardless of input voltage variations up to plus or minus 10 percent.
 - d. Ammeter and Voltmeter: Flush mounted in door. Meters indicate charging rates.
 - e. Safety Functions: Include sensing of abnormally low battery voltage arranged to close contacts providing low battery voltage indication on control and monitoring panel. Also include sensing of high battery voltage and loss of ac input or dc output of battery charger. Either condition closes contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
 - f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.
 - g. Battery Heater: Provide battery heater for outdoor generator installations.

2.12 CONTROL AND MONITORING

- A. Functional Description: When the 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 the generator set. When the mode-selector switch is switched to the on position, the generator set manually starts. The off position of the same switch initiates generator-set shutdown. When the generator set is running, specified system or equipment failures or derangements automatically shut down the generator set and initiate alarms. Operation of a remote emergency-stop switch also shuts down the generator set.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages are grouped on a common control and monitoring panel mounted on the generator set. Mounting method isolates the control panel from generator-set vibration.
 1. Current and Potential Transformers: Instrument accuracy class.
- C. Indicating and Protective Devices and Controls: Include those required by NFPA 110 for a Level 1 system, and the following:

- D. Indicating and Protective Devices and Controls: Include the following:
1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. Engine-coolant temperature gage.
 6. Engine lubricating-oil pressure gage.
 7. Running-time meter.
 8. Ammeter-voltmeter, phase-selector switch(es).
 9. Generator-voltage adjusting rheostat.
 10. Permanent Generator Offline for Maintenance
 11. Generator overload.
- E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices, and wiring required to support specified items. Locate sensors and other supporting items on engine, generator, or elsewhere as indicated. Where not indicated, locate to suit manufacturer's standard.
- F. Provide connection to BAS system with a minimum of 10 points of generator status as outlined in BAS specification. Provide BACNET and MODBUS protocol compatible with BAS system to be coordinated with building controls contractor.
- G. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Locate audible device and silencing means where indicated.
- H. Monitoring generator remote start circuits: Comply with NFPA 70, Section 700.10 to continuously monitor generator control wiring. Loss of integrity shall initiate visual and audible annunciation of the generator malfunction and local generator location and annunciator location and the loss of integrity shall start up the generator.
- I. Remote Alarm Annunciator: Communications ready and installed by twisted pair wiring. Comply with NFPA 99. Labeled LEDs identify each alarm event. Common audible signal sounds for alarm conditions. Silencing switch in face of panel silences signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
- J. Remote Emergency-Stop Switch: Flush wall-mounted, unless otherwise indicated and prominently labeled. Push button is protected from accidental operation.

2.13 GENERATOR OVERCURRENT AND FAULT PROTECTION

- A. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
1. Tripping Characteristic: Designed specifically for generator protection.
 2. Trip Rating: Matched to generator rating.
 3. Shunt Trip: For future use.
 4. Mounting: Adjacent to or integrated with control and monitoring panel.
 5. Kirk Key:

- a. Provide with auxiliary contacts to indicate if generator is offline for maintenance.
 - b. Interlock with temporary generator connection switch breaker with same Kirk Key Lock.
- B. Ground-Fault Indication: Comply with NFPA 70, Article 700-7(d). Integrate ground-fault alarm indication with other generator-set alarm indications.

2.14 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1 and specified performance requirements.
- B. Drive: Generator shaft is directly connected to engine shaft. Exciter is rotated integrally with generator rotor.
- C. Electrical Insulation: Class H or Class F.
- D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.
- E. Construction prevents 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.
- F. Excitation uses no slip or collector rings, or brushes, and is arranged to sustain generator output under short-circuit conditions as specified.
- G. Enclosure: Dripproof.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel provides plus or minus 5 percent adjustment of output- voltage operating band.
- I. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- J. Alternator 105C rise rated. Provide alternator heater with circuit wired to it.

2.15 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph . Multiple panels are lockable and provide adequate access to components requiring maintenance. Panels are removable by one person without tools. Instruments and control are mounted within enclosure. Provide skid bottom end plates.
- B. Description: Prefabricated or pre-engineered enclosure with the following features:
 - 1. Construction: Galvanized steel, metal-clad on steel frame.
 - 2. Sound Attenuating Enclosure: Provide sound attenuation.
 - 3. Structural Design and Anchorage: Adequate to resist loads imposed by 100-mph wind.
 - 4. Space Heater: Thermostatically controlled operating at one-half or less of rated voltage sized to prevent condensation.

5. Louvers: Equipped with insect/rodent screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust and rodents.
 6. Hinged Doors: With padlocking provisions.
 7. Ventilation: Louvers equipped with insect/rodent screen and filter arranged to permit air circulation while excluding exterior dust and rodents.
 8. Thermal Insulation: As required to maintain winter interior temperature within limits required by components.
 9. Finish: Two-coat enamel finish over cleaned and primed surfaces.
- C. Muffler Location: Internal to enclosure.
- D. Engine Cooling Airflow through Enclosure: Adequate to maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for two hours with ambient temperature at top of range specified in system service conditions.
- E. Louvers: Fixed-engine cooling air inlet and discharge. Louvers prevent entry of rain and snow.
- F. Automatic Dampers (for units 500kW or larger): At engine cooling air inlet and discharge. Dampers are fixed type.
- G. Interior Lights: With switch. Factory-wired, LED vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external circuit supply.
- H. Convenience Outlets: Factory wired. Arrange for external circuit supply.
- I. 500kVA and above to be supplied with integral auxiliary panel to supply power to generator charger, alternator heater, block heater and all other accessories.

2.16 FINISHES

- A. Indoor Enclosures and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.
- B. Outdoor Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and compatible standard primer.

2.17 SOURCE QUALITY CONTROL

- A. Factory Tests: Include prototype testing and Project-specific equipment testing (testing of equipment manufactured specifically for this Project).
- B. Prototype Testing: Performed on a separate engine generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 1. Tests: Comply with those required for Level 1 energy converters in Paragraphs 3.2.1, 3.2.1.1, and 3.2.1.2 of NFPA 110.
 2. Generator Tests: Comply with IEEE 115.
 3. Components and Accessories: Items furnished with installed unit that are not identical to those on tested prototype have been tested to demonstrate compatibility and reliability.

- C. Project-Specific Equipment Tests: Factory test engine generator set and other system components and accessories before shipment. Perform tests at rated load and power factor. Include the following tests.
 - 1. Full load run.
 - 2. Maximum power.
 - 3. Voltage regulation.
 - 4. Transient and steady-state governing.
 - 5. Single-step load pickup.
 - 6. Safety shutdown.
- D.
- E. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Examine roughing-in of cooling-system piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

3.2 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for packaged engine generators. Refer to Division 03 Section "Cast-in-Place Concrete."

3.3 INSTALLATION

- A. Packaged Engine Generator sets shall be installed in accordance with NECA/EGSA 404-2000, Recommended Practice for Installing Generator Sets (ANSI).
- B. Comply with packaged engine generator manufacturers' written installation and alignment instructions, and with NFPA 110.
- C. Set packaged engine generator set on concrete bases.
 - 1. Support generator-set mounting feet on rectangular metal blocks and shims or on metal wedges having small taper, at points near foundation bolts to provide 3/4- to 1-1/2-inch gap between pump base and foundation for grouting.
 - 2. Adjust metal supports or wedges until generator is level.
- D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
 - 1. Verify that electrical wiring is installed according to manufacturers' submittal and installation requirements in Division 26 Sections. Proceed with equipment startup only after wiring installation is satisfactory.
- F. The Electrical Contractor shall provide initial filling of diesel fuel tank with fresh fuel. Top off tank at substantial completion.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties. The following are specific connection requirements:
 - 1. Install piping adjacent to packaged engine generator to allow service and maintenance.
 - 2. Connect water supply to cooling system.
 - 3. Connect cooling-system water supply and drain piping to diesel-engine heat exchangers. Install flexible connectors at connections to engine generator and remote radiator.
 - 4. Connect exhaust-system piping to diesel engines.
- B. Electrical wiring and connections are specified in Division 26 Sections.
- C. Ground equipment.
 - 1. Provide at least (3) ground rods at generator.
 - 2. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 IDENTIFICATION

- A. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."

3.6 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections, and to assist in testing. Report results in writing.
- B. Testing: Perform field quality-control testing under the supervision of the manufacturer's factory-authorized service representative.
- C. Tests: Include the following:
 - 1. Factory standard tests recommended by manufacturer.
 - 2. Perform each visual and mechanical inspection and electrical and mechanical test stated in NETA ATS for emergency engine generator sets, except omit vibration baseline test

3. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110. The authority having jurisdiction (Office of Fire Safety, Michigan Department of Consumer and Industry Services) shall be given advanced notification of the time at which the final test is to be performed so that the authority can witness the test. Provide signed documentation to the authority having jurisdiction documenting that these code requirements have been met. Loadbank test to full capacity for 4 hours in addition to building load test.
 4. Battery Tests: 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. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.
 5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 6. 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.
 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 under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.**
 9. **Load Bank Test: Perform a four hour load bank test at generator rated capacity.]**
- D. Coordinate tests with tests for transfer switches and run them concurrently.
- E. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- F. 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.
- G. Test instruments shall have been calibrated within the last 12 months, traceable to standards of the National Institute for Standards and Technology, and adequate for making positive observation of test results. Make calibration records available for examination on request.
- 3.7 BATTERY EQUALIZATION
- A. Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
- 3.8 CLEANING
- A. On completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators as specified below:
1. Coordinate this training with that for transfer switches.
 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 3. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
 4. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 5. Minimum Instruction Period: Eight hours.

END OF SECTION 26 3213

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SECTION 26 3600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.
 - 2. Bypass/isolation switches.
 - 3. Nonautomatic transfer switches.
 - 4. Dual Purpose Generator / Load Bank Docking Station
 - 5. Generator Docking Station
 - 6.
- B. Related Sections include the following:
 - 1. Division 21 Section "Electric-Drive, Centrifugal Fire Pumps" for automatic transfer switches for fire pumps.
 - 2. Division 21 Section "Electric-Drive, Vertical-Turbine Fire Pumps" for automatic transfer switches for fire pumps.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
 - 1. Single-Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Dimensioned 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.

B. Field quality-control test reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Features and operating sequences, both automatic and manual.
 2. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Maintain a service center capable of providing training, parts, and emergency maintenance repairs within a response period of less than eight hours from time of notification.
- B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain automatic transfer switches, bypass/isolation switches, and remote annunciator and control panels through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NEMA ICS 1.
- F. Comply with NFPA 70.
- G. Comply with NFPA 99.
- H. Comply with NFPA 110.
- I. Comply with UL 1008 unless requirements of these Specifications are stricter.

1.7 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service:
 - 1. Notify Architect Construction Manager, and Owner no fewer than ten days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Owner's written permission.

1.8 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.9 WARRANTY

- A. General Warranty: Special warranty specified in this Article shall not deprive Owner of other rights. Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.
- B. Special Warranty: Written warranty, executed by manufacturer agreeing to repair or replace transfer switch and auxiliary components that fail in materials of workmanship within specified warranty period. The warranty shall have no deductibles.
 - 1. Warranty Period: Five years from date of Substantial Completion.
 - 2. Warranty to include: parts, labor and travel time for five years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Conventional Transfer Switches:
 - a. Cummins Power Generation; Industrial Business Group.
 - b. Generac Power Systems, Inc.
 - c. Caterpillar; Engine Div.
 - d. Emerson; ASCO Power Technologies, LP.
 - e. GE Zenith Controls.
 - f. Kohler Power Systems; Generator Division.
 - g. Trystar
 - h. Russelectric, Inc.
 - i. Spectrum Detroit Diesel.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
 - 1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
 - 2. When fault-current value is not indicated on transfer switch, meet or exceed the KA fault current rating of upstream panel with "any breaker" fully rated available fault current rating.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
- F. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
 - 1. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
 - 2. Switch Action: Double throw; mechanically held in both directions.
 - 3. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
- G. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles.
- H. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
- I. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
 - 2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
 - 3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
- J. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.3 AUTOMATIC TRANSFER SWITCHES

- A. Comply with Level 1 equipment according to NFPA 110.
- B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
- C. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
- D. Signal-before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
- E. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled, unless both sources are live.
- F. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
- G. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
- H. Automatic Transfer-Switch Features:
 - 1. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
 - 2. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
 - 3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
 - 4. Provide with Phase angle monitoring between phases, phase rotation sensing and digital fault history display.
 - 5. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
 - 6. Retransfer to Normal Source Transition time: Provide a 5 second transition time from Generator to Normal source to prevent nuisance tripping of breakers.

7. Test Switch: Simulate normal-source failure.
8. Switch-Position Pilot Lights: Indicate source to which load is connected.
9. 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."
10. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
11. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
12. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
13. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
14. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
15. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
 - a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
 - b. Push-button programming control with digital display of settings.
 - c. Integral battery operation of time switch when normal control power is not available.

2.4 BYPASS/ISOLATION SWITCHES

- A. Comply with requirements for Level 1 equipment per NFPA 110.
- B. 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:
 1. Means to lock bypass/isolation in the position that isolates transfer switch, with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
 2. Drawout Arrangement for Transfer Switch: Provides physical separation from live parts and accessibility for testing and maintenance operations.
 3. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with the same phase arrangement and number of poles.
 4. Contact temperatures of bypass/isolation switches do not exceed those of automatic transfer-switch contacts when they are carrying rated load.

5. Operability: Constructed so load bypass and transfer-switch isolation can be performed by one person in no more than two operations in 15 seconds or less.
 6. Legend: Manufacturer's standard legend for control labels and instruction signs give detailed operating instructions.
 7. Maintainability: Fabricate to allow convenient removal of major components from the front without removing other parts or main power conductors.
- C. 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.

2.5 NONAUTOMATIC TRANSFER SWITCHES

- A. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- B. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
- C. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.
- D. Nonautomatic Transfer-Switch Accessories:
1. Pilot Lights: Indicate source to which load is connected.
 2. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternate-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
 3. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.

2.6 DUAL PURPOSE GENERATOR / LOAD BANK DOCKING STATION

- A. Dual purpose docking station shall include two sets of temporary Generator Camlocks and one set of lugs. One set, readily accessible, for connection of a temporary load bank feeding into shunt trip breaker. The second set shall feed into Kirk-key interlocked breaker interlocked with permanent generator main circuit breaker so that a portable generator breaker cannot be closed to the load bus while permanent generator breaker is closed.
1. Use Trystar DBDS-6 or equal.
- B. Entire package must be listed to ETL or UL 1008 Standards. UL listing of individual components is not acceptable.
- C. Enclosures:

1. NEMA 3R rain-tight aluminum enclosure.
 - a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or load bank. NEMA 3R integrity shall be maintained with access plate open for cable entry.
 - b. Front and side through a front access panel shall be accessible for maintenance.
 - c. Top, side and bottom through a front access panel shall be accessible for permanent cabling.
 - D. Phase, Neutral, and Ground Buses:
 1. Material: Silver-plated Copper
 2. Equipment Ground Bus: bonded to box.
 3. Isolated Ground Bus: insulated from box.
 4. Ground Bus: 50% of phase size.
 5. Neutral Bus: Neutral bus rated 100 percent of phase bus.
 6. Round edges on bus.
 - E. Load bank and portable generator connectors shall be Camlok style mounted on gland plate (male for the portable generator and female for the portable load bank). Male Camlocks to be behind door. Female Connection to feed through breaker with Kirk Key interlocked with permanent generator main breaker.
 1. Camlok shall be color coded according to system voltage
 - F. Permanent connections shall be broad range set-screw type, located behind an aluminum barrier.
 - G. Voltage & Amperage shall be as shown on project one line drawing.
- 2.7 GENERATOR DOCKING STATION
- A. Docking station shall include one set of temporary Generator Camlocks and one set of lugs. The connection shall feed into Kirk-key interlocked breaker interlocked with permanent generator main circuit breaker so that a portable generator breaker cannot be closed to the load bus while permanent generator breaker is closed.
 1. Use Trystar SBDS3 or equal.
 - B. Entire package must be listed to ETL or UL 1008 Standards. UL listing of individual components is not acceptable.
 - C. Enclosures:
 1. NEMA 3R rain-tight aluminum enclosure.
 - a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of cables from portable generator or load bank. NEMA 3R integrity shall be maintained with access plate open for cable entry.
 - b. Front and side through a front access panel shall be accessible for maintenance.
 - c. Top, side and bottom through a front access panel shall be accessible for permanent cabling.
 - D. Phase, Neutral, and Ground Buses:

1. Material: Silver-plated Copper
 2. Equipment Ground Bus: bonded to box.
 3. Isolated Ground Bus: insulated from box.
 4. Ground Bus: 50% of phase size.
 5. Neutral Bus: Neutral bus rated 100 percent of phase bus.
 6. Round edges on bus.
- E. Portable generator connectors shall be Camlok style mounted on gland plate. Camlok to be female Connection and to feed through breaker with Kirk Key interlocked with permanent generator main breaker.
1. Camlok shall be color coded according to system voltage
- F. Permanent connections shall be broad range set-screw type, located behind an aluminum barrier.
- G. Voltage & Amperage shall be as shown on project one line drawing.

2.8 FINISHES

- A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.9 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Four-Pole Switches: Where four-pole switches are indicated, install neutral switching.

3.2 INSTALLATION

- A. Floor-Mounted Switch: Level and anchor unit to floor.
- B. Floor-Mounting Switch: Anchor to floor by bolting.
1. Concrete Bases: 4 inches high, reinforced, with chamfered edges. Extend base no more than 4 inches in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."
- C. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
- D. Identify components according to Division 26 Section "Identification for Electrical Systems."

- E. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.3 CONNECTIONS

- A. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.
- B. Generator Run Status to Elevator
 - 1. Provide conduit and wire between the transfer switch and each elevator controller.
 - 2. Notify each elevator controller when the building is operating on emergency power
- C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified independent testing and inspecting agency to perform tests and inspections and prepare test reports.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
- C. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
 - 2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
 - a. Check for electrical continuity of circuits and for short circuits.
 - b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - c. Verify that manual transfer warnings are properly placed.
 - d. Perform manual transfer operation.
 - 5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.

- d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- 6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- D. Testing Agency's Tests and Inspections:
 - 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. 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.
 - 4. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time-delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer-switch operations.
 - f. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
 - g. 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.
 - 5. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - a. Verify grounding connections and locations and ratings of sensors.
- E. Coordinate tests with tests of generator and run them concurrently.
- F. 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.

- G. Remove and replace malfunctioning units and retest as specified above.
- H. Infrared Scanning: After Substantial Completion, but not more than 30 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
 - 1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.
 - 2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action. Include scanning results.

3.5 CLEANING

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

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:
 - 1. Coordinate this training with that for generator equipment.
 - 2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.
 - 3. Review data in maintenance manuals. Refer to Division 01 Section "Closeout Procedures."
 - 4. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data."
 - 5. Schedule training with Owner, through Architect, with at least seven days' advance notice.
 - 6. Provide a minimum of four hours of instruction.

END OF SECTION 26 3600

SECTION 26 4313 - SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 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 field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

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.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.
 - 3. Submit test report data clearly demonstrating the maximum surge current rating has been tested on a COMPLETE SPD unit including all necessary fusing/overcurrent protection, thermal disconnects, integral disconnects and monitoring systems. Manufacturers who cannot provide this data will not be approved.

4. Submit data demonstrating that the SPD unit is capable of surviving the specified minimum repetitive surge current rating. The rating is based on surviving a specified number of ANSI/IEEE C62.41, Category C-High (10kA) impulses without failure or degradation in performance characteristics of more than 10%.

5.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For SPDs to include in maintenance manuals.

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace SPDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, acceptable manufacturers are as follows with no substitutions:

1. RayCap.

2.2 GENERAL SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be at least 125 percent of the nominal system voltage.

2.3 SERVICE ENTRANCE / ESSENTIAL LOCATION AND TRANSFER SWITCH

- A. The manufacturer shall provide a surge protective device that is classified by UL-1449 as a Type 2 device intended for installation on the load side of the main disconnect. The unit shall also be tested and listed to be installed as a 1-port (parallel) or 2-port device (In-line/Kelvin).
- B. SPD shall be rated for a 480Y/277 volt, 60 Hertz, 3-phase, 4-wire system and shall be mounted externally to the main switchboard low-voltage switchgear Distribution Power Panel, and connected in parallel to the power path through a dedicated circuit breaker.
- C. Nominal Current Discharge Level (I_n): The peak value of surge current through the SPD, selected by the manufacturer, having a current wave-shape of $8 \times 20 \mu s$ where the SPD remains functional after 15 surges shall be 20kA per mode.
- D. Impulse Current (I_{imp}): The service entrance device shall be capable of surviving direct strike transient ($10 \times 350 \mu s$) without failure or degradation of performance. Provide 3rd party test data confirming this, using minimum 12.5kA I_{imp} .
- E. Temporary Overvoltage (TOV) Survivability: The units shall be able to at a minimum survive 60 cycles (1s) of varying TOV levels.
- F. The service entrance SPD will be capable of surviving 600 IEC, $10 \times 350 \mu s$ waveforms of 5kA impulses without failure or degradation of original performance characteristics of more than 5%.
- G. Unit shall have a maximum surge current rating of 200,000 amperes L-N, 200,000 amperes L-G, and 200,000 amperes N-G, based on ANSI/IEEE C62.41 standard 8 by 20 microsecond current waveform.
- H. The SPD will be modular in design. Separate and replaceable suppression modules will protect each mode (L-N, L-G, and N-G).
- I. The system shall be constructed using multiple surge current diversion modules utilizing a single metal oxide varistor (MOV) and high capacity thermal electrode ensuring max surge current capacity can pass through the SPD without degradation or failure.

Service Entrance SPD Device Selection							
System Voltage	Switchboard Amps	SPD Model	Surge Rating	Protection Modes	Max Wire Size	Max Breaker Amps	Time Stamp Event Monitoring
208/120V Wye	Up to 2000A	120-3Y-N3-7-04-A-H	140kA/Mode	L-N, L-G, N-G	4/0	200	Yes
208/120V Wye	2000A-4000A	120-3Y-A1-7-04-A-H	200kA/Mode	L-N, L-G, N-G	4/0	200	Yes
480/277V Wye	Up to 2000A	277-3Y-N3-7-04-C-H	140kA/Mode	L-N, L-G, N-G	4/0	200	Yes
480/277V Wye	2000A-4000A	277-3Y-A1-7-04-C-H	200kA/Mode	L-N, L-G, N-G	4/0	200	Yes
480 Delta	Up to 2000A	480-3D-M3-3-04-D-H	140kA/Mode	L-G	#2 AWG	100	Yes
480 Delta	2000A-4000A	480-3D-N1-3-04-D-H	200kA/Mode	L-G	#2 AWG	100	Yes

PRODUCT DATA SHEET 1 - Unit shall provide maximum UL 1449, Voltage Protection Rating (VPR) as follows:

S', 'M', 'N' and 'A' are	ANSI/UL 1449 4th Edition
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enclosure sizes; '1' = 80mm MOV; '3' = 40mm MOV		Rayvoss Enclosure VPR							
		In-Line (Kelvin)				T-Connection (Parallel)			
Service Type	Enclosure	L-L	L-N	L-G	N-G	L-L	L-N	L-G	N-G
120 Sin- gle Phase	S3	X	1000	500	500	X	1200	800	700
	M1	X	900	500	500	X	1200	800	800
120/240 Split Phase	N3	900	900	600	700	1200	1200	700	700
	M1	900	900	500	500	1200	1200	800	800
120/208 Wye	N3	900	900	600	700	1200	1200	700	700
	A1	900	900	600	600	1200	1200	800	800
240 Delta	N3	1800	X	1000	X	2000	X	1200	X
	M1	1800	X	900	X	2000	X	1200	X
277/480 Wye	M3	2500	1200	1200	1200	2500	1500	1500	1500
	M1	1500	1200	1000	1000	2500	1500	1500	1200
480 Delta	M3	3000	X	1500	X	3000	X	1800	X
	M1	2500	X	1500	X	3000	X	1500	X

2.1 Non Service Entrance Rated

- A. The manufacturer shall provide a surge protective device that is classified by UL-1449, as a Type 1 or 2 device.
- B. SPD shall be rated for a [480Y/277] [208Y/120] volt, 60 Hertz, 3-phase, 4-wire system and shall be mounted externally to the [switchboard] [low-voltage switchgear] [Distribution Power Panel], and connected in parallel to the power path through a dedicated circuit breaker.
- C. Nominal Current Discharge Level (I_n): The peak value of surge current through the SPD, selected by the manufacturer, having a current wave-shape of 8x20ms where the SPD remains functional after 15 surges shall be 20kA per mode.
- D. Quality: The manufacturer shall be ISO 9001 certified, demonstrating world-class quality systems for the design and manufacture of the SPD units.
- E. Unit shall be UL 1449, Most Recent Edition Listed. An SPD that is a UL "Recognized" component will not be accepted.
- F. Each surge suppression element (MOV) shall utilized a stacked MOV design.
- G. Unit shall provide maximum UL 1449, Voltage Protection Rating (VPR) for 208Y/120 Volt systems as follows:
 1. L-N = 600V
 2. L-G = 600V
 3. N-G = 600V
 4. L-L = 1000V
- H. Unit shall provide maximum UL 1449, Voltage Protection Rating (VPR) for 480Y/277 Volt systems as follows:
 1. L-N = 1000V
 2. L-G = 1200V
 3. N-G = 1200V
 4. L-L = 1800V
- I. Unit shall have a maximum surge current rating of 50,000 amperes or 100,000 amperes L-N, 50,000 amperes or 100,000 amperes L-G, and 50,000 amperes or 100,000 amperes N-G, based on ANSI/IEEE C62.41 standard 8 by 20 microsecond current waveform.
- J. Unit shall include dry contacts, LEDs, audible alarm, and a surge/TOV counter w/ time & date stamp.

- K. The SPD will be connected to the panelboard bus bar through a dedicated, minimum 30-amp breaker. Table below indicates acceptable breaker and wire ranges.

Branch Panel SPD Device Selection						
System Voltage	Switchboard Amps	SPD Model	Surge Rating	Protection Modes	Max Breaker Amps	Time Stamp Event Monitoring
208/120V Wye	Up to 400A	RSE-2-120-3Y-A-05-E-F-S	50kA/Mode	L-N, L-G, N-G	30-100	Yes
208/120V Wye	400A-2000A	RSE-2-120-3Y-A-10-E-F-S	100kA/Mode	L-N, L-G, N-G	60-125	Yes
480/277V Wye	Up to 400A	RSE-2-277-3Y-A-05-E-F-S	50kA/Mode	L-N, L-G, N-G	30-100	Yes
480/277V Wye	400A-2000A	RSE-2-277-3Y-A-10-E-F-S	100kA/Mode	L-N, L-G, N-G	60-125	Yes

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be at least 115 percent of the nominal system voltage.

2.2 SERVICE ENTRANCE SUPPRESSOR

- A. SPDs: Comply with UL 1449, Type 2.
- B. Raycap Rayvoss Series
- C. SPDs: Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1449, Type 2
 - 1. SPDs with the following features and accessories:
 - a. Mounted externally to switchboard/panelboard, and fed by a dedicated circuit breaker.
 - b. Tested and certified to meet UL 3-cycle test, allowing SPD to coordinate with any breaker. SPD shall not require internal fusing protection.
 - c. Indicator light display for protection status.
 - d. Unit shall have a Form C summary alarm output contact rated for at least 1 amp at 120VAC for remote annunciation of SPD status.
 - e. Advanced monitoring, displayed through an integrated color LCD display, that includes real time measurements for voltage, current, frequency, power factor, kW, kVAR, kVA. The monitor should also include an event counter with time & date stamp, user settable alarm thresholds and an embedded web page for remote monitoring.
 - f.
- D. Comply with UL 1283.
- E. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per mode shall not be less than 140 kA. Surge rating shall conform to selection table and project drawings.

- F. The VPR Table above covers VPRs for various voltage configurations. DELETE this section and the next section.
- G. SCCR: Equal or exceed 200 kA.
- H. Inominal Rating: 20 kA.
- I. Enclosure: The unit shall at minimum have a heavy duty NEMA 12 dust-tight, drip-tight enclosure unless specified otherwise.

2.3 PANEL SUPPRESSORS

- A. SPDs: Comply with UL 1449, Type 2.
- B. Raycap: RSE Series
 - 1. Unit shall include solid-state, long-life externally mounted LED visual status indicators that indicate the on-line status and operational integrity of each phase of the unit.
 - 2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 3. Unit shall have a Form C summary alarm output contact rated for at least 1 amp at 120VAC for remote annunciation of SPD status.
 - 4. Unit shall have a surge/TOV counter with time & date stamp.
- C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per mode shall not be less than 50 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- D. Comply with UL 1283.
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 1200 V for 480Y/277 V 600 V for 208Y/120 V.
 - 2. Line to Ground: 1200 V for 480Y/277 V 600 V for 208Y/120 V.
 - 3. Neutral to Ground: 1200 V for 480Y/277 V 600 V for 208Y/120 V.
 - 4. Line to Line: 1800 V for 480Y/277 V 1200 V for 208Y/120 V
- F. Protection modes and UL 1449 VPR for 240/120-V, single-phase, three-wire circuits shall not exceed the following:
 - 1. Line to Neutral: 600 V.
 - 2. Line to Ground: 600 V.
 - 3. Neutral to Ground: 600 V.
 - 4. Line to Line: 900 V.
- G. SCCR: Equal or exceed 200 kA.
- H. Inominal Rating: 20 kA.

2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 4.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. SPD units shall be field installed externally to their respective branch circuit panelboard, distribution panel, motor control center or switchboard enclosure.
- C. Install devices at service entrance on load side with dedicated circuit breaker feed, with ground lead bonded to service entrance ground.
- D. Install conductors between suppressor and points of attachment as short and straight as possible. Desired lead length for phase and neutral conductors is 16 inches or less. In no case, shall the leads exceed 30 inches. Do not bond neutral and ground.
 - 1. Provide multipole, circuit breaker (size in accordance with manufacturer's recommendations) as a dedicated disconnect for the suppressor, unless otherwise indicated.
- E. After testing, disable or disconnect SPD unit until time of substantial completion. This is to eliminate deterioration of the unit during construction period.
- F. Wiring:
 - 1. Power Wiring: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Controls: Comply with wiring methods in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized, and tested.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION 26 4313

SECTION 26 5100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, LED modules and drivers.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.
5. Retrofit kits for LED lighting fixtures.

B. Related Sections:

1. Division 26 Section "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Division 26 Section "Network Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.
3. Division 26 Section "Wiring Devices" for manual wall-box dimmers for incandescent lamps.

1.2 ACTION SUBMITTALS

- A. General: Some lighting fixtures may require at least 3 to 4 months of lead time. The Contractor is responsible for allowing sufficient time for the review process, manufacturing and delivery of these products. Substitutions will not be accepted on the basis of the Contractor's obligation to meet project completion deadlines.
- B. Lighting Fixtures Specified: The lighting fixtures specified in these documents have been carefully chosen for their ability to meet lighting requirements for this project. Selection has been based on esthetics, durability, ease of maintenance, luminance ratios, vertical and horizontal illuminances, lumen maintenance, CRI, efficacy, LED system life and warranty as well as their ability to satisfy governing codes such as ASHRAE/IES 90.1/1999. The Contractor is cautioned that substitute products are likely to be unable to meet all of the same criteria as the product specified.
- C. Substitutions: When proposing substitute products, the Contractor shall be responsible for the negotiation with the Owner and Architect/Engineer, prior to substitution submittal, to assure fees are available to redesign the project based on the proposed substitutions or review by the Architect/Engineer of all photometric, sample, design and calculations for the proposed substitutions. All substitutions must be identified at time of bid. The Contractor's bid value shall not be based on substitutions in expectation of design team approval, nor on the Contractor's estimated value of the products specified. If review of the proposed substitute light fixtures finds the product unacceptable, the Contractor shall provide the fixtures specified at no additional cost to the Owner or delay in the project completion time.
- D. Product Data: For each type of lighting fixture and lamp indicated, arranged in order of fixture designation. Submit fixture data in bound brochure. Include illustrations and dimensions of fixtures, and showing photometric performance. Include data on features, accessories, and the following:

1. Contract Drawing light fixture type designation.
 2. Dimensions of fixtures.
 3. Certified results of independent laboratory tests of fixtures and lamps for electrical ratings and photometric data.
 4. Emergency lighting unit battery and charger.
 5. LED fixture LM79, LM80 and TM21 testing data.
 6. Written Warranty Compliance
- E. Lighting Fixture Submittals: Fixture cuts lacking sufficient detail to indicate compliance with specifications will not be acceptable.
- F. Shop Drawings: Show details of nonstandard and custom fixtures. Indicate dimensions, weights, components, features, accessories, and methods of field assembly and mounting.
1. Wiring Diagrams: Detail wiring for fixtures and differentiate between manufacturer-installed and field-installed wiring.
- G. Maintenance Data: For lighting fixtures to include in maintenance manuals specified in Division 01.

1.3 QUALITY ASSURANCE

- A. Fixtures, Emergency Lighting Units, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
- B. Comply with NFPA 70.
- C. Comply with LM 79, LM80 and TM21 LED testing standards.
- D. FM Compliance: Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM.
- E. NFPA 101 Compliance: Comply with visibility and luminance requirements for exit signs.
- F. Office of Fire Safety: All plastic diffusers used in lighting fixtures or luminous ceilings shall conform with NFPA 101, Life Safety Code, 1997 Edition, Section 6-5, Interior Finish. The light fixture manufacturer(s) shall furnish an affidavit stating compliance with this requirement for submittal to the State of Michigan Department of Labor & Economic Growth, Office of Fire Safety, P.O. Box 30254, Lansing, Michigan 48909.

1.4 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.5 WARRANTY

- A. Special Warranty for Batteries: Written warranty, executed by manufacturer agreeing to replace rechargeable batteries that fail in materials or workmanship within specified warranty period.

1. Special Warranty Period for Batteries: Manufacturer's standard 5 years from date of Substantial Completion. Full warranty shall apply for all 5 years.
- B. Warranty for LED fixtures: Written warranty, agreeing to replace drivers, LED modules and any fixture housing or components that fail in materials and workmanship within minimum (5) years from date of purchase. Warranty shall provide materials necessary to restore to acceptable operation. Labor shall be warrantied for two years of the project substantial completion. The warranty shall include fixture replacement or component replacement if the luminaire delivers less than 90% of the initial light level over the rated life.
 1. For decorative pendant and track fixtures, warranty shall be minimum of (5) years.
 2. All other fixtures shall match the standard warranty of the fixture specified.

PART 2 - PRODUCTS

2.1 LIGHTING FIXTURE MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

2.2 FIXTURES AND FIXTURE COMPONENTS, GENERAL

- A. Metal Parts: Free from burrs, sharp corners, and edges.
- B. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.
- D. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
 4. Laminated Silver Metallized Film: 90 percent.
- E. Lenses, Diffusers, Covers, and Globes: 100 percent virgin acrylic plastic or annealed crystal glass, unless otherwise indicated.
 1. Plastic: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
 2. Lens Thickness: 0.125 inch (3 mm) minimum, unless greater thickness is indicated.
- F. Disconnecting Means: Provide disconnecting means for all LED fixtures. Disconnect shall comply with NEC Section 410.73(G).

1.

2.3 LED FIXTURES

A. GENERAL

1. LED light fixtures shall meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
2. LED light fixtures shall be sold as a complete system. Light fixtures shall have minimum efficacy as follows:
 - a. Linear Recessed LED (2x2,2x4,1x4,1x2): 95 Lumens per watt.
 - b. Linear Recessed LED (~4", Narrow Aperture): 74 Lumens per watt.
 - c. Linear Pendant LED (~4" Aperture): 95 Lumens per watt up, 74 Lumens per watt down.
 - d. Downlight LED: 80 Lumens per watt.
3. LED light fixtures shall have delivered lumen output within 5% of the delivered lumen output of the fixtures specified.
4. LED light fixtures shall be dimmable down to 20% or less of full output. If the specified fixture is dimmable to a level lower than 20%, equivalent fixture must be dimmable to the same level or lower than the fixture specified.
5. LED light fixture shall produce no noticeable variation in color temperature from one fixture to another by the same manufacturer. Color temperature shall be within 3-step MacAdam Ellipse.

B. LED DRIVERS

1. High performance LED driver to be 120/277V and wired for dimming or non-dimming. Provide with manufacturer tested compatible battery backup where indicated.
2. Driver expected lifetime shall be over 100,000 hours.
3. Total Harmonic Distortion Rating: Less than 20 percent.
4. Minimum power factor shall be 94%.

C. LED ENGINES

1. Manufacturers: Refer to light fixture schedule, light fixture is ordered as a complete system including LED driver, light engine and housing from the LED light fixture manufacturer.
2. LED Color Temperature and Minimum Color-Rendering Index:
 - a. Downlights: 4100 K and over 85 CRI
 - b. Linear LED: 4100 K and over 80 CRI
3. LED Life:
 - a. Downlights: Rated average shall be 50,000 hours rated per LM79, LM80 and TM-21 standards.
 - b. Linear LED: Rated average shall be 100,000 hours rated per LM79, LM80 and TM-21 standards.
 - c. Track and pendant heads: Rated average shall be 50,000 hours to 70% rated per LM79, LM80 and TM-21 standards.

2.4 EXIT SIGNS

- A. General Requirements: Comply with UL 924 and the following:
 - 1. Refer to Lighting Fixture Schedule on the plans.
- B. Internally Lighted Signs: Features as follows:
 - 1. Lamps for AC Operation: Light-emitting diodes, 70,000 hours minimum rated lamp life.
- C. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.
 - 1. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - 2. Charger: Fully automatic, solid-state type with sealed transfer relay.
 - 3. Operation: Relay automatically energizes lamp from unit when circuit voltage drops to 80 percent of nominal or below. When normal voltage is restored, relay disconnects lamps, and battery is automatically recharged and floated on charger.
- D. Wire Guard: Provide heavy chrome plated wire guards to protect fixtures installed in gymnasiums and multi-purpose rooms.

2.5 FINISHES

- A. Fixtures: Manufacturer's standard, unless otherwise indicated.
 - 1. Paint Finish: Applied over corrosion-resistant treatment or primer, free of defects.
 - 2. Metallic Finish: Corrosion resistant.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.
- D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.
- E. Wires for Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gage.
- F. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- G. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Interior Lighting Systems shall be installed in accordance with NECA/IESNA 500, Recommended Practice for Installing Indoor Commercial Lighting Systems and NECA/IESNA 502-2011, Recommended Practice for Installing Industrial Lighting Systems.
- B. Fixtures: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials.
- C. Support for Fixtures in or on Grid-Type Suspended Ceilings: Support fixture using grid plus the following:
 - 1. Fixtures shall be positively attached to the ceiling grid system.
 - 2. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from fixture corners.
 - 3. Support Clips: Fasten to fixtures and to ceiling grid members at or near each fixture corner.
 - 4. Fixtures of Sizes Less Than Ceiling Grid: Arrange as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently of panel, with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
- D. Suspended Fixture:
 - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Fixtures: Suspend with two separate stem hangers.
 - 3.
 - 4. Continuous Rows: Suspend from cable installed according to fixture manufacturer's written instructions and details on Drawings.
 - 5. Fixtures to be aligned and level, insure lenses are fastened properly in place.
 - 6. Any supports used to suspend fixture in exposed ceiling areas shall be installed as high as possible out of view and painted with ceiling.
 - 7. Mount remote type drivers out of site above ceilings or in painted enclosure.
 - 8. Coordinate installation so that no pipes, cable tray, duct work, etc are routed below light fixtures. Light fixtures shall be at a set plane so similar fixture types are all the same height or as noted on plans. Notify architects and engineers of any obstructions that will not allow for light to be installed at desired location.
- E. In Mechanical and Boiler Rooms, coordinate lighting fixture installation with mechanical piping, duct work, etc. Provide all required supporting rods and channel to bridge duct work and piping. Generally, mount fixtures 8-9 feet above floor unless noted otherwise. Avoid positioning above mechanical piping and ducts.

3.2 CONNECTIONS

- A. Ground equipment.
 - 1. Tighten electrical connections and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 IDENTIFICATION

- A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Provide instruments to make and record test results.
- C. Tests:
 - 1. Verify normal operation of each fixture after installation.
 - 2. Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.
 - 3. Verify normal transfer to battery source and retransfer to normal.
- D. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units are acceptable.
- E. Corroded Fixtures: Replace during warranty period.

3.5 STARTUP SERVICE

- A. Burn-in all fixtures that require specific aging period to operate properly, prior to occupancy by Owner.

3.6 CLEANING AND ADJUSTING

- A. Clean fixtures internally and externally after installation. Fixture cones, reflectors, baffles, and visible trim shall be turned over to the owner clean and free of dust, drywall mud, smudges, fingerprints, and scratches. Only use methods and cleaning materials in accordance with respective fixture manufacturer recommendations.
- B. All adjustable light fixtures shall be aimed, focused and locked by the Contractor under the observation of the Architect/Engineer. When daylighting interferes with the aiming and focusing, aiming shall be accomplished during hours of darkness.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting aimable luminaires to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Some of this work may be required after dark.
 - 1. Adjust aimable luminaires in the presence of Architect.

END OF SECTION 26 5100

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SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Exterior luminaires with LED modules and drivers.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.

1.2 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
 - a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
6. Photoelectric relays.
7. LED fixture compliance of lumen maintenance, CRI, efficacy and LED system rated life and warranty.
8. LED fixture LM79, LM80 and TM21 testing data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
4. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include lamps and ballasts.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.
- D. LED fixture written warranty compliance.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and poles 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.
 - 1. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 10 of each type and rating installed. Furnish at least one of each type.
 - 2. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.6 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.
- 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 IEEE C2, "National Electrical Safety Code."
- D. Comply with NFPA 70.
- E. LED fixtures to be tested in compliance with LM79, LM80 and TM21 testing standards.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

- C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.
- D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.
- E. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.
 - 1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.
 - 5. Warranty Period for LED fixtures: Minimum (5) years from date of Substantial Completion.
 - a. LED fixture warranty shall state agreement to replace LED drivers, LED light engine modules, fixture housing, components or accessories under the warranty coverage term.
 - b. Warranty shall include replacement of fixtures or components if the luminaire delivers less than 90% of the initial light level over the 100,000 hour life.
 - c. Fixture warranty to be extended to meet all requirements at a minimum of the warranty of the basis of design fixture specified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated for each designation in the Lighting Fixture Schedule on the plans.

2.2 LUMINAIRES

- A. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- B. Metal Parts: Free from burrs, sharp corners, and edges.
- C. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

- D. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- E. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit servicing without use of tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during servicing and when secured in operating position. Provide for door removal for cleaning or replacing lens. Arrange to disconnect driver when door opens.
- F. Exposed Hardware Material: Stainless steel.
- G. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and ultraviolet radiation.
- H. Reflecting Surfaces: Minimum reflectance as follows, unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- I. Fixture to be provided with all required accessories including (but not limited to) Luminaire, Arm or Mount, Pole, specified accessories.
- J. Lenses and Refractors: Materials as indicated. Use heat- and aging-resistant, resilient gaskets to seal and cushion lens and refractor in luminaire doors.
- K. Photoelectric Relays: As follows:
 - 1. Contact Relays: Single throw, arranged to fail in the on position and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay.
 - 2. Relay Mounting: In luminaire housing.

2.3 LED LIGHT FIXTURES:

- A. Light fixtures shall be UL listed and meet all of the specified parameters with published independent testing in accordance with LM79, LM80 and TM21 testing standards.
- B. Light fixtures shall be sold as a complete system. Light fixtures shall have a minimum efficacy of 75 lumens per watt or equal to that of the light fixture specified.
- C. Light fixtures shall have rated delivered lumen output within 5% of the rated delivered lumen output of the fixture specified.
- D. Light fixtures shall have accessible and replaceable drivers and LED light engine boards.
- E. LED drivers shall be 120/277V or 480V to match specified. LED drivers and light engines shall be Class 1 and have 100,000 hour rated life.
- F. Exterior fixtures to have one dimming driver per fixture head where dimming drivers are specified.
- G. LED driver Total Harmonic distortion shall be less than 20%.

- H. Light fixture minimum power factor shall be 90%.
- I. Light fixture color temperature shall be 4000K and minimum 90 CRI.
- J. Transient voltage surge suppression shall be 10kV integral to the fixture in accordance with IEEE/ANSI C62.41.2.
- K. Fixture shall be dark sky friendly.
- L. Fuses: One in each ungrounded supply conductor. Voltage and current ratings as recommended by ballast manufacturer. Fuses shall be installed in handhole near base of pole, not at fixture head.
- M. Occupancy Sensor: When occupancy sensor on the fixture is specified, the fixture shall be equipped with an integral passive infrared occupancy sensor device that changes the light level by dimming the light engine.
 - 1. The sensor shall also have the capability of providing ambient light sensing and adjusting light levels accordingly.
 - 2. The sensor shall have an adjustable time delay feature.
 - 3. The low and high dimming shall be field adjustable.

2.4 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

- A. Comply with UL 773 or UL 773A.
- B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
 - 1. Relay with locking-type receptacle shall comply with ANSI C136.10.
 - 2. Adjustable window slide for adjusting on-off set points.

2.5 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

- A. Structural Characteristics: Comply with AASHTO LTS-4-M.
 - 1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
 - 2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.
- B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.
- C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
 - 1. Materials: Shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
 3. Anchor-Bolt Template: Plywood or steel.
- D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless-steel captive screws.
- E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."
- F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.
- G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.6 ALUMINUM POLES

- A. Poles: Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6 with access handhole in pole wall.
- B. Poles: ASTM B 209, 5052-H34 marine sheet alloy with access handhole in pole wall.
1. Shape: Round, tapered.
 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- D. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.
1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 2. Finish: Same as luminaire.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.
- G. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear Anodic Finish: AA-M32C22A41 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.
 - a. Color: As selected by Architect from manufacturer's full range.

2.7 POLE ACCESSORIES

- A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.
 1. Recessed, 12 inches above finished grade.
 2. Nonmetallic polycarbonate plastic or reinforced fiberglass, weatherproof in use, cover, color to match pole, that when mounted results in NEMA 250, Type 3R enclosure.
 3. With cord opening.
 4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.
- B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.
- C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.2 POLE INSTALLATION

- A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.
- B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:
 1. Fire Hydrants and Storm Drainage Piping: 60 inches.
 2. Water, Gas, Electric, Communication, and Sewer Lines: 5 feet.

3. Trees: 10 feet from tree trunk.
 - C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."
 - D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
 1. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 2. Install base covers unless otherwise indicated.
 3. 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.
 - E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 1. Dig holes large enough to permit use of tampers in the full depth of hole.
 2. Backfill in 6-inch layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.
 - F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 1. Make holes 6 inches in diameter larger than pole diameter.
 2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi at 28 days, and finish in a dome above finished grade.
 3. Use a short piece of 1/2-inch- diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
 4. Cure concrete a minimum of 72 hours before performing work on pole.
 - G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch below top of concrete slab.
 - H. Raise and set poles using web fabric slings (not chain or cable).
- 3.3 BOLLARD LUMINAIRE INSTALLATION
- A. Align units for optimum directional alignment of light distribution.
 - B. Install on concrete base with top 4 inches above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 Section "Cast-in-Place Concrete."

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

- A. 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 Division 03 Section "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 Division 26 Section "Raceway 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 GROUNDING

- A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole.
 - 2. Install grounding conductor and conductor protector.
 - 3. Ground metallic components of pole accessories and foundations.

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed unit for damage. Replace damaged units.
- B. Advance Notice: Give dates and times for field tests.
- C. Provide instruments to make and record test results.
- D. Tests and Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source, and as follows:
 - 1. Measure light intensities at night if specific illumination performance is indicated. Use photometers with calibration referenced to NIST standards.
 - 2. Check intensity and uniformity of illumination.
 - 3. Check excessively noisy ballasts.
- E. Prepare a written report of tests, inspections, observations and verifications indicating and interpreting results.

- F. Malfunctioning Fixtures and Components: Replace or repair, then retest. Repeat procedure until units operate properly.

3.8 CLEANING AND ADJUSTING

- A. Clean units after installation. Use methods and materials recommended by manufacturer.
- B. Adjust aimable luminaires and luminaires with adjustable lamp position to provide required light distributions and intensities.

END OF SECTION 26 5600

SECTION 27 0500 – COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 Documents

- A. This section of the of the specification is part of the contract documents and is to be read, interpreted and coordinated with all other parts.

1.2 Summary

- A. Section Includes:
 - 1. Overview
 - 2. Abbreviations
 - 3. Contractor Qualifications
 - 4. Standards and Guidelines
 - 5. Quality Assurance
 - 6. Permits and Inspections

1.3 Overview

- A. This document must be read, interpreted and coordinated with all other related specifications to deliver a complete Telecommunications infrastructure system.
- B. This specification prescribes mandatory requirements for the Telecommunications infrastructure system.
- C. A structured approach is specified which will ensure a flexible distribution system that will minimize the future costs of moves, additions and changes.
- D. The Contractor will supply, furnish, and install all material, labor, tools, equipment and services required for construction and put into regular operation the complete Telecommunications system as shown on the Telecommunications drawings, described in the specifications, and any attached appendices.
- E. Any and all proposed changes to this specification shall be subject to approval in writing to the Architect prior to implementation.

1.4 Abbreviations

- A. 8P8C: 8-position, 8-contact
- B. ANSI: American National Standards Institute
- C. ASTM: American Society for Testing and Materials
- D. 10Gig: 10-Gig Active Ethernet

- E. 10GPON: 10-Gigabit Symmetrical Passive Optical Network
- F. A/V: Audio Visual
- G. AC: Alternating Current
- H. ADN: Area Distribution Node
- I. APC: Angled Physical Contact
- J. BICSI: Building Industry Consulting Service International.
- K. Coated RMC: PVC Coated Rigid Metallic Conduit
- L. UL: Listed by Underwriters Laboratories (United States)
- M. EIA: Electronic Industries Alliance
- N. EMI: Electromagnetic Interference
- O. EMT: Electrical Metallic Tubing
- P. ENT: Electrical Non-metallic Tubing
- Q. ER: Equipment Room
- R. DC: Direct Current
- S. EF: Entrance Facility
- T. GRC: Galvanized rigid steel conduit
- U. IMC: Intermediate metal conduit
- V. IDF: Intermediate Distribution Frame
- W. AHJ: Authority Having Jurisdiction
- X. LAN: Local Area Network
- Y. MDF: Main Distribution Frame
- Z. MPTL: Modular Plug Terminated Link
- AA. OSP: Outside Plant Wiring
- BB. PDU: Power Distribution Unit
- CC. PoE: Power over Ethernet
- DD. RCDD: BICSI Registered Communications Distribution Designer

- EE. RGS: Rigid Galvanized Steel
- FF. RU: Rack Unit
- GG. SFP: Small Form Pluggable
- HH. SMF: Single Mode Fiber
- II. STP: Shielded Twisted Pair
- JJ. TDMM: Telecommunications Distribution Methods Manual (BICSI)
- KK. TECH: BICSI Technician
- LL. TIA: Telecommunications Industry Association
- MM. TR: Telecommunications Room
- NN. UPS: Uninterruptable Power Supply
- OO. UTP: Unshielded Twisted Pairs
- PP. UPC: Ultra Physical Contact
- QQ. WAO: Work Area Outlet
- RR. WAP: Wireless Access Point

1.5 Contractor Qualifications

- A. The Contractor will have experience in the installation and testing of similar systems as specified herein and will have completed at least two projects of similar size and scope within the last 24 months. The contractor will provide references upon request (including the project name, address, date of implementation, client name, title, telephone number and project description).
- B. All members of the installation team must be certified by the Manufacturer as having completed the necessary training to complete their part of the installation. All personnel will be adequately trained in the use of such tools and equipment as required.
- C. The Contractor must be certified to install a certified fire-stop system.
- D. The Contractor will own and maintain tools, installation equipment, and test equipment necessary for successful installation and testing of optical and Category 6 and 6a premise distribution systems.
- E. The Contractor must maintain a state Contractor's license as required by the state.
- F. The Contractor installing the structured cabling shall have a Registered Communication Distribution Designer (RCDD) and a Project Superintendent.
- G. The Contractor's lead installer shall have a current BICSI TECH certification and shall be onsite for the duration of the project.

1.6 Standards and Guidelines

- A. The following organizations publish telecommunications construction standards with provisions that, through reference in this text, constitute provisions of this Document. At the time of publication of this Document, the editions of the standards published by the organizations indicated were valid. Installers of telecommunications and networking services for this project must adhere to the telecommunication standards published by these organizations, all standards are subject to revision; parties to agreements based on this Document shall apply the most recent editions of the standards published by the organizations indicated.

1. Federal Communications Commission (FCC)
2. Institute of Electrical and Electronics Engineers, Inc (IEEE)
3. National Fire Protection Association (NFPA)
4. National Electrical Safety Code (NESC)
5. American National Standards Institute (ANSI)
6. Telecommunications Industry Association (TIA)
7. Electronic Industries Alliance (EIA)
8. Building Industry Consulting Service International (BICSI)

B. Applicable Standards and Guidelines

1. The following list of methods and standards included are considered part of this specification. This is a list of primary references and does not limit the applicability of other standards that are incorporated into the work described in these specifications. They incorporate generally accepted communications infrastructure practices described in Standards documents (and addenda) published by recognized standards bodies and organizations. These include standards published by the Telecommunications Industry Association/Electronics Industries Alliance (TIA/EIA) and Building Industry Consultant Services International (BICSI).
 - a. ANSI/TIA/ EIA 568B, Commercial Building Telecommunications Cabling Standard
This prescribes the requirements for Intrabuilding copper and optical fiber cable performance, installation and testing
 - b. ANSI/TIA/EIA 569B, Telecommunication Standard for Pathways and Spaces. This standard includes specifications for the design and construction of pathways and spaces within buildings required to support information technology equipment and cable media.
 - c. ANSI/TIA/EIA 607, Commercial Building Grounding and Bonding Requirement. This document includes the components of an effective grounding system for communication systems within public and commercial buildings.
 - d. ANSI/TIA/EIA 758, BICSI Customer Owned Outside Plant Telecommunications Cabling
 - e. Standard. This standard provides specifications for Interbuilding communication facilities that
 - f. include cable media, pathways and spaces.
 - g. ANSI/TIA/EIA 862, Building Automation Systems Cabling Standard for Commercial Buildings. This standard describes the generic cable system for building automation systems (BAS) that are intended to support a multi-product, multi-vendor automation environment within public and commercial buildings.
 - h. Building Industry Consulting Services International (BICSI) Telecommunications Distribution Methods Manual, 14th Edition. This is a manual of proven design guidelines and methods accepted by the telecommunications industry.
 - i. ANSI/NFPA 70, National Electrical Code, (NEC) Current Edition. In addition to standards related to electrical safety, the NEC has several sections that specifically address low voltage cable installation.

1.7 Quality Assurance

- A. The latest National Electrical Code shall be observed and shall govern the character of work, style, quantity and the size of all material used.
- B. All materials shall conform with the standards of the Underwriter's Laboratories in every case where such standards have been established for the particular type of material in question.
- C. All material and equipment shall be UL listed and bear the UL label where such listing and labeling exists.
- D. The complete electrical installation shall comply with all the requirements of the M.I.O.S.H.A.
- E. Codes shall be used as minimum requirements, and where the Specifications or Plans call for an installation that exceeds and does not violate the Code requirements, the Specifications and Plans shall be followed.

1.8 Permits and Inspections

- A. The Contractor shall obtain and pay for all permits required by the State of Michigan Labor Department, Electrical Division.
- B. The Contractor shall submit, to precede request for final payment, a copy of the Certificate of Inspection as required by the State of Michigan.

END OF SECTION 27 0500

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SECTION 27 0526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.
 - 4. Grounding labeling.

1.2 DEFINITIONS

- A. TBC: Telecommunications Bonding Conductor
- B. SBB: Secondary Bonding Busbar
- C. PBB: Primary Bonding Busbar
- D. BBC: Bonding Backbone Conductor
- E. RBB: Rack Bonding Busbar

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - 1. Ground rods.
 - 2. Ground and roof rings.
 - 3. TBC, PBB, SBBs, and routing of their bonding conductors.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Installation Supervision: Installation shall be under the direct supervision of a BICSI Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 2. Field Inspector: Currently registered by BICSI as a Technician to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM COMPONENTS

- A. Comply with TIA-607-C.

2.2 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Harger Lightning and Grounding.
 - 2. Panduit Corp.
 - 3. Chatsworth Products.
- B. Comply with UL 486A-486B.
- C. Insulated Conductors: Stranded copper wire, green or green with yellow stripe insulation, insulated for 600 V, and complying with UL 83.
 - 1. Ground wire for custom-length equipment ground jumpers shall be No. 6 AWG, 19-strand, UL-listed, Type THHN wire.
 - 2. Cable Tray Equipment Grounding Wire: No. 6 AWG.
- D. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmils, 14 strands of No. 17 AWG conductor, and 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Tinned-copper tape, braided conductors terminated with two-hole copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

2.3 CONNECTORS

- A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Burndy; Part of Hubbell Electrical Systems.
 2. Chatsworth Products, Inc.
 3. Harger Lightning and Grounding.
 4. Panduit Corp.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless compression-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch centers for a two-bolt connection to the busbar.
- E. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Chatsworth Products, Inc.
 2. Harger Lightning and Grounding.
 3. Panduit Corp.
- B. PBB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as PBB and shall comply with TIA-607-C.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide a 2-inch
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. SBB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches in cross section, length as indicated on Drawings. The busbar shall be for wall mounting, shall be NRTL listed as complying with UL 467, and shall comply with TIA-607-C.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide at least a 2-inch
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- D. Rack and Cabinet Grounding Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-607-C. Predrilling shall be with holes for use with lugs specified in this Section.
1. Rack-Mounted Horizontal Busbar: Designed for mounting in 19-inch equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 - a. Chatsworth 10610-019 or approved equal.

2.5 LABELING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brother International Corporation.
 - 2. Dymo.
 - 3. Panduit Corp.
- B. Comply with TIA-606-Band UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the ac grounding electrode system and equipment grounding for compliance with requirements for maximum ground-resistance level and other conditions affecting performance of grounding and bonding of the electrical system.
- B. Inspect the test results of the ac grounding system measured at the point of TBC connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the TBC only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-C.

3.3 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
 - 1. The bonding conductors between the SBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.
 - 2. The bonding conductors between the PBB and structural steel of steel-frame buildings shall not be smaller than No. 6 AWG.

- B. Underground Grounding Conductors: Install bare copper conductor, No. 2 AWG minimum.
- C. 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 Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.
- D. Conductor Support:
 - 1. Secure grounding and bonding conductors at intervals of not less than 36 inches.
- E. Grounding and Bonding Conductors:
 - 1. Install in the straightest and shortest route between the origination and termination point, and no longer than required. The bend radius shall not be smaller than eight times the diameter of the conductor. No one bend may exceed 90 degrees.
 - 2. Install without splices.
 - 3. Support at not more than 36-inch intervals.
 - 4. Install grounding and bonding conductors in 3/4-inch PVC conduit until conduit enters a telecommunications room. The grounding and bonding conductor pathway through a plenum shall be in EMT. Conductors shall not be installed in EMT unless otherwise indicated.
 - a. If a grounding and bonding conductor is installed in ferrous metallic conduit, bond the conductor to the conduit using a grounding bushing that complies with requirements in Section 27 0528 "Pathways for Communications Systems," and bond both ends of the conduit to a SBB.

3.4 GROUNDING ELECTRODE SYSTEM

- A. The TBC between the PBB and the ac service equipment ground shall not be smaller than No. 1/0 AWG.

3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches minimum from wall, minimum 12 inches above finished floor unless otherwise indicated.
- B. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.

3.6 CONNECTIONS

- A. Bond metallic equipment in a telecommunications equipment room to the grounding busbar in that room, using equipment grounding conductors not smaller than No. 6 AWG.
- B. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- C. Assemble the wire connector to the conductor, complying with manufacturer's written instructions and as follows:

1. Use crimping tool and the die specific to the connector.
 2. Pretwist the conductor.
 3. Apply an antioxidant compound to all bolted and compression connections.
- D. Primary Protector: Bond to the PBB with insulated bonding conductor.
- E. Interconnections: Interconnect all SBBs with the PBB with the telecommunications backbone conductor. If more than one PBB is installed, interconnect PBBs using the backbone bonding conductor. The telecommunications backbone conductor and backbone bonding conductor size shall not be less than 2 kcmils/linear foot of conductor length, up to a maximum size of No. 3/0 AWG (168 kcmils) unless otherwise indicated.
- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install top-mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the SBB No. 2 AWG bonding conductors.
- G. Structural Steel: Where the structural steel of a steel frame building is readily accessible within the room or space, bond each SBB and PBB to the vertical steel of the building frame.
- H. Electrical Power Panelboards: Where an electrical panelboard for telecommunications equipment is located in the same room or space, bond each SBB to the ground bar of the panelboard.
- I. Shielded Cable: Bond the shield of shielded cable to the SBB in communications rooms and spaces. Comply with TIA-568.1-D and TIA-568-C.2 when grounding screened, balanced, twisted-pair cables.
- J. Rack- and Cabinet-Mounted Equipment: Bond powered equipment chassis to the cabinet or rack grounding bar. Power connection shall comply with NFPA 70; the equipment grounding conductor in the power cord of cord- and plug-connected equipment shall be considered as a supplement to bonding requirements in this Section.
- K. Access Floors: Bond all metal parts of access floors to the SBB.

3.7 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
1. Label PBB(s) with "fs-PBB," where "fs" is the telecommunications space identifier for the space containing the PBB.
 2. Label SBBs) with "fs-SBB," where "fs" is the telecommunications space identifier for the space containing the SBB.
 3. Label the TBC and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:

1. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 2. Test the bonding connections of the system using an ac earth ground-resistance tester, taking two-point bonding measurements in each telecommunications equipment room containing a PBB and a SBB and using the process recommended by BICSI TDMM. Conduct tests with the facility in operation.
 - a. Measure the resistance between the busbar and the nearest available grounding electrode. The maximum acceptable value of this bonding resistance is 100 milliohms.
 3. Test for ground loop currents using a digital clamp-on ammeter, with a full-scale of not more than 10 A, displaying current in increments of 0.01 A at an accuracy of plus/minus 2.0 percent.
 - a. With the grounding infrastructure completed and the communications system electronics operating, measure the current in every conductor connected to the PBB and in each SBB. Maximum acceptable ac current level is 1 A.
- C. Excessive Ground Resistance: If resistance to ground at the TBC exceeds 5 ohms, notify Architect promptly and include recommendations to reduce ground resistance.
- D. Grounding system will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 27 0526

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SECTION 27 0528 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cable Tray
2. Non-Continuous Cable Supports.

B. Related Requirements:

1. Division 26 Section "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.
2. Division 28 Section "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.2 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets.

PART 2 - PRODUCTS

2.1 CABLE TRAY

- A. The installation of new structured cabling shall be installed in cable trays, where it exists.
- B. If cable tray does not exist, installer shall install non-continuous cable supports.

2.2 NON-CONTINUOUS CABLE SUPPORTS

A. General Requirements for non-continuous cable supports:

1. Shall be UL Listed
2. Shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance cables per ANSI/TIA 568.0-D
3. Shall have flared edges to prevent damage while installing cables Comply with TIA-569-D.
4. Shall have a cable retainer wire form to provide containment of cables within the hanger. The cable retainer shall be removable and reusable.
5. Shall have a hot-dipped galvanized or G60 finish and shall be rated for indoor use in non-corrosive environments.

6. Acceptable products: PENTAIR CADDY CAT32HP, CAT48HP, CAT64HP or approved equal.
7. Non-continuous cable supports shall be a minimum of 2 inches.

B. Installation

1. Installation and configuration shall conform to the requirements of the current revision levels of ANSI/ EIA/TIA Standards 568 & 569, NFPA 70 (National Electrical Code), applicable local codes, and to the manufacturer's installation instructions.
2. Install cables using techniques, practices, and methods that are consistent with Category 5e or higher requirements and that supports Category 5e or higher performance of completed and linked signal paths, end to end.
3. Install cables without damaging conductors, shield, or jacket.
4. Do not bend cables, in handling or in installing, to smaller radii than minimums recommended by manufacturer or by TIA 568.
5. Pull cables without exceeding cable manufacturer's recommended pulling tensions or outlined in TIA 569. Use pulling means that will not damage media.
6. Do not exceed load ratings specified by manufacturer.
7. Non-continuous supports shall be installed a minimum 3 inches above ceilings.
8. Non-continuous supports shall be installed so there is no more than 5ft between supports, measured horizontally.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. 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.
- C. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.
- D. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- E. 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.
- F. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- G. Pathways Embedded in Slabs:
 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure pathways to reinforcement at maximum 10-foot intervals.
 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings.
 3. Arrange pathways to keep a minimum of 1 inch of concrete cover in all directions.

4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
- H. Stub-ups to Above Recessed Ceilings:
1. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- I. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- J. 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.
- K. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- L. 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.
- M. Spare Pathways: Install pull strings in empty pathways. Cap underground pathways designated as spare above grade alongside pathways in use.
- N. Surface Pathways:
1. Install surface pathway for surface telecommunications outlet boxes only where indicated on Drawings.
- O. Pathways for Optical-Fiber and Communications Cable: Install pathways 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.
- P. Install pathway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound.
- Q. 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.
- R. 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 conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.

2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - 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.
- S. Mount boxes at heights indicated on Drawings in accordance with ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- T. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

3.2 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.3 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.

END OF SECTION 27 0528

SECTION 27 0536 – LADDER RACK FOR TELECOMMUNICATION ROOMS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Ladder Rack.
 - 2. Ladder Rack Accessories.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product and all accessories.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 01 4000 "Quality Requirements," to design cable tray supports and seismic bracing.

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.
- B. Structural Performance: See articles on individual cable tray types for specific values for uniform load distribution, concentrated load, and load and safety factor parameters.

2.3 LADDER RACK

- A. Manufacturers: Refer to drawing for model and part number.
- B. Installation
 - 1. Install ladder rack as shown on drawings and details.
 - a. Refer to enlarged Telecommunication Room drawings.
 - b. Refer to Telecommunication Room rack elevations for vertical ladder rack installation.
 - 2. Individual sections of ladder shall be bonded together with factory made bonding jumpers
 - 3. Ladder rack shall be bonded to PBB/SBB
- C. Description:

1. Configuration: Refer to drawings.
2. Color: Black
3. Width: 12 inches in IT Rooms unless otherwise indicated on Drawings.
4. Minimum Usable Load Depth: 1.5 inches.
5. Straight Section Lengths: 10 feet, except where shorter lengths are required to facilitate tray assembly.
6. Radius-Fitting Rung Spacing: 9 inches at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch width with radius edges.
8. No portion of the rungs shall protrude below the bottom plane of side rails.
9. 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.
10. Fitting Minimum Radius: 12 inches.
11. Maximum uniform load and support span are indicated by cable tray class. See "Load/Span Classification System" Article in the Evaluations.
12. Splicing Assemblies: Bolted type using serrated flange locknuts.
13. Splice-Plate Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

D. Materials and Finishes:

1. Steel:
 - a. Straight Section and Fitting Side Rails and Rungs: Steel complies with the minimum mechanical properties of ASTM A 1011/A 1011M, SS, Grade 33.
 - b. Steel Tray Splice Plates: ASTM A 1011/A 1011M, HSLAS, Grade 50, Class 1.
 - c. Fasteners: Steel complies with the minimum mechanical properties of ASTM A 510/A 510M, Grade 1008.
 - d. Finish: Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123 M, Class B2.
 - e. Finish: Hot-dip galvanized after fabrication, complying with ASTM A 653/A 653M, G90.
 - f. Finish: Electrogalvanized after fabrication, complying with ASTM B 633.
 - 1) Hardware: Galvanized, ASTM B 633.
 - g. Finish: Epoxy-resin or Powder-coat enamel paint.
 - 1) Powder-Coat Enamel: Cable tray manufacturer's recommended primer and corrosion-inhibiting treatment, with factory-applied powder-coat paint.
 - 2) Epoxy-Resin Prime Coat: Cold-curing epoxy primer, MPI# 101.
 - 3) Epoxy-Resin Topcoat: Epoxy, cold-cured gloss, MPI# 77.
 - h. Finish: Factory-standard primer, ready for field painting, with chromium-zinc-plated hardware according to ASTM F 1136.
 - i. Finish: Black oxide finish for support accessories and miscellaneous hardware according to ASTM D 769.

2.4 LADDER RACK ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. 90 Degree Runway-Splice Kit.
- C. Butt-Splice Kit.
- D. Cable Runway Elevation Kit.

- E. Foot Kit, Cable Runway.
- F. Junction-Splice Kit.
- G. Triangular Support Bracket, Steel.
- H. Vertical Wall Brackets.
- I. Wall Angle Support Kit, Cable Runway.
- J. Cable Runway Grounding Strap Kit.
- K. Cable Runway Radius Drop, Cross Member.
 - 1. Install one Radius Drop above each rack mount vertical cable manager.
- L. Protective End Caps for Runway.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. 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.
- B. Fasten cable tray supports to building structure.
- C. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of 200 lb.
- D. 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.
- E. Seal penetrations through fire and smoke barriers. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- F. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- G. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
- H. 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 27 0526 "Grounding and Bonding for Communications Systems."

- B. Cable trays with shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. 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 to cable trays every 18 inches (use Velcro only).
- C. Fasten cables on vertical runs to cable trays every 18 inches (use Velcro only).
- 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.

3.4 FIELD QUALITY CONTROL

- A. Perform the following 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 retorquing in suspect areas.
 - 7. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
 - 8. 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.

3.5 PROTECTION

- A. Protect installed cable trays and cables.

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END OF SECTION 27 0536

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SECTION 27 0553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Color and legend requirements for labels.
2. Labels.
3. Cable ties.
4. Hook & Loop (Velcro).
5. Fasteners for labels and signs.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

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. White letters on a Black 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: computer printed, 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: Permanent, waterproof black ink marker recommended by tag manufacturer.
 - 3. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
 - 4. Hand written labels are not approved.
- 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 CABLE TIES

- 1. Cable ties are not allowed in any permanent installation.
- 2. Any cable tie used during installation, on a temporary basis, shall be removed prior to project completion.

2.5 Hook & Loop (Velcro)

- 1. All cables to be bundled using Hook & Loop products (Velcro)
- 2. Panduit Part # HLS-75R0 or approved equal.
 - a. Use white Hook & Loop with white cable horizontal cable.
 - b. Use black Hook & Loop with all other cable colors.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. 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 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. Verify identity of each item before installing identification products.
- C. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- F. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- G. Self-Adhesive Wraparound Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label within 12 inches from each cable end.
- H. 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.

3.2 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. Refer to detail drawings
- 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.
- 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.
 - 1. Fiber optic cables shall be labeled on each end within 12 inches of where fiber cable enters enclosure.
- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:
 - 1. Refer to detail drawings.
- H. Instructional Signs: Self-adhesive labels.
- I. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.
 - 1. Apply to exterior of door, cover, or other access.
- J. 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 27 0553

SECTION 27 1116 – TELECOMMUNICATION ROOM EQUIPMENT AND RACKS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. 19-inch Equipment Racks.
2. Cable Management.
3. Rackmount Uninterruptable Power Supply (UPS).
4. Rackmount Power Distribution Unit (PDU).
5. Plywood Backboard.
6. Grounding.

1.2 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. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- 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 TGB and its mounting detail showing standoff insulators and wall-mounting brackets.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- B. Seismic Qualification Data: Certificates, from manufacturer.

1.5 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 or a BICSI Technician.
2. Installation Supervision: Installation shall be under direct supervision of a BICSI 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 a 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 19-INCH EQUIPMENT RACKS

- A. Description: The data equipment rack shall meet EIA-310D standards and be constructed of extruded aluminum or steel capable of accepting 19" wide EIA equipment. Rack construction method shall ensure an electrically bonded structure for ease of grounding. The 3" channel rack shall be UL listed for 1000 lbs. load. The equipment mounting rails shall be double-sided #12-24 EIA universal mounting hole spacing. The equipment mounting rails shall include printed rack space identification on the front and back and be numbered up.
- B. Manufacturers: Refer to drawing for manufacturer and part number.
- C. General Requirements:
 1. Frames: Modular units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 2. Material: Extruded aluminum.
 3. Finish: Manufacturer's standard, baked-polyester powder coat.
 4. Color: Black.
- D. Floor-Mounted Racks:
 1. Load Rating: 200 lb.
 2. Number of Rack Units per Rack: 45.
 3. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
 4. Base shall have a minimum of four mounting holes for permanent attachment to floor.
 5. Top shall have provisions for attaching to cable tray or ceiling.
 6. Self-leveling.

2.3 RACKMOUNT UNINTERRUPTABLE POWER SUPPLY (UPS)

- A. Description: Horizontal rack-mount style with rack ears.

- B. Manufacturers: Refer to drawings for model and part number.

2.4 RACKMOUNT POWER DISTRIBUTION UNIT (PDU)

- A. Description: Horizontal rack-mount style with rack ears.
- B. Manufacturers: Refer to drawings for model and part number.

2.5 PLYWOOD BACKBOARD

- A. Description: 4ft x 8ft plywood, $\frac{3}{4}$ " thick on walls of Telecommunication Rooms.
- B. General Requirements:
 - 1. 4ft x 8ft
 - 2. $\frac{3}{4}$ " thick
 - 3. A/C grade plywood with A side facing inside of Telecommunications Room
 - 4. Each sheet of plywood to mounted vertically.
 - 5. Refer to drawings for elevations.

2.6 GROUNDING

- A. Comply with requirements in Section 27 0526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Chatsworth Products, Inc.
 - 2. Harger Lightning & Grounding.
- C. Rack Busbars: Rectangular bars of hard-drawn solid copper, accepting conductors ranging from No. 14 to No. 2/0 AWG, NRTL listed as complying with UL 467, and complying with TIA-606-B. Predrilling shall be with holes for use with lugs specified in this Section.
 - 1. Rack-Mounted Horizontal Busbar: Designed for mounting in 19-inch equipment rack. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.

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 PBB to minimize length of bonding conductors. Fasten to wall, allowing at least 2 inches of clearance behind PBB. Connect PBB with a minimum No. 4 AWG grounding electrode conductor from PBB to suitable electrical building ground. Connect rack Busbar to near PBB.
 - 1. Bond the shield of shielded cable to patch panel, and bond patch panel to PBB.

END OF SECTION 27 1116

SECTION 27 1323 - COMMUNICATIONS OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. New fiber optic cabling shall be installed throughout the building. Refer to project drawings for a fiber riser diagram. Multimode fiber shall be installed between Telecommunication Rooms.
- B. Section Includes:
 - 1. Multimode Fiber Optic Cable
 - 2. Fiber Optic Enclosures
 - 3. Fiber Optic Terminations
 - 4. Fiber Optic Adapter Panels
 - 5. Fiber Optic Patch Cables
 - 6. Cabling identification products.

1.2 OPTICAL FIBER BACKBONE CABLING DESCRIPTION

- A. Optical fiber backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.3 ACTION SUBMITTALS

- A. Panduit Certified Installer Certificate
- B. BICSI Technician Certificate
- C. Fiber Optic Cable
- D. Fiber Optic Enclosures
- E. Fiber Optic Terminations
- F. Fiber Optic Fiber Adapter Panels
- G. Fiber Optic Patch Cables
- H. Shop Drawings: Reviewed by RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.

2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration Drawings and printouts.
4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of product.
- B. Installer Credentials:
 1. Panduit Certified Installer (PCI) verification is required for each onsite installation technician.
 2. BICSI TECH verification is required for onsite lead installation technician.
 3. Valid certificates shall be provided to TowerPinkster prior to project kick-off.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data.
 1. As-built drawings.
 - a. As-built drawings shall be in PDF format.
 - b. No hand-written drawings shall be accepted.
 - c. See attached as-built sample for requirements.
 - d. Refer to section 2.8 in this specification.
 2. Certification results for all installed cables (PDF & Certification tester format)
 - a. See attached sample of certification test result for requirements.
 - b. Refer to section 2.7 in this specification.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer is preferred to have personnel certified by BICSI on staff.
 1. Layout Responsibility: Preparation of Shop Drawings, cabling administration Drawings, and field-testing program development by a BICSI TECHNICIAN.
 2. Installation Supervision: Installation shall be under the direct supervision of a BICSI TECHNICIAN, who shall be present at all times when Work of this Section is performed at Project site.
 3. Testing Supervisor: Currently certified by BICSI as a TECHNICIAN to supervise on-site testing.
- B. Testing Agency Qualifications: Testing agency is preferred to have personnel certified by BICSI on staff.
 1. Testing Agency's Field Supervisor: Currently certified by BICSI as a TECHNICIAN.

1.7 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Backbone 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 MULTIMODE FIBER OPTIC CABLE

- A. Description: OFCP, Multimode, tight buffer, 12-strand, distribution interlock, armored, plenum, optical fiber cable.
- B. Standards:
 - 1. Comply with TIA-492CAAA for detailed specifications.
 - 2. Comply with TIA-568-C.3 for performance specifications.
 - 3. Comply with ICEA S-83-596 for mechanical properties.
 - 4. Comply with ETL Listed Type OFCP
- C. Armored cable shall be aluminum armored type (ILPA).
- D. Jacket:
 - 1. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.
 - 2. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.
- E. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - 1. Plenum Rated, Armored (Conductive): Type OFCP, complying with NFPA 262.
- F. Manufacturer
 - 1. Refer to drawing details for manufacturer and part number.

2.3 FIBER OPTIC ENCLOSURES

- A. Description: 1u, rackmount fiber enclosure to house fiber terminations and/or splices.
- B. Standards:
 - 1. Comply with Optical Fiber Connector Intermateability Standard specifications of the TIA-604 series.
 - 2. Comply with TIA-568-C.3.
 - 3. 1u rack mount

4. Black
5. Sliding tray
6. Accepts 4 Fiber Adapter Panels (FAP)
7. Front Access.

C. Manufacturer

1. Refer to drawing details for manufacturer and part number.

2.4 FIBER OPTIC TERMINATIONS

- A. LC form factor Fusion-Splice Connectors shall be FOCIS-10 compatible (for LC), and include a pre-polished fiber which eliminates the need for field polishing and adhesives.
- B. The connectors shall be composed of a ferrule assembly with integral fiber, a front housing, and a rear assembly, plus additional components as necessary by connector type (including angled physical contact polish).
- C. The connectors shall exceed TIA/EIA-568-D.3 performance requirements for IL and RL, and have a functional temperature range from -40°C to 75°C.
- D. These splice-on connectors shall be compatible with Sumitomo brand splice units.
- E. Connector Type: Simplex LC
- F. Polish: UPC
- G. Insertion Loss: 0.15dB average
- H. Return Loss: >55dB
- I. Manufacturer
 1. Refer to drawing details for manufacturer and part number(s).

2.5 FIBER OPTIC ADAPTER PANELS

- A. Fiber adapter panels contain TIA/EIA-604 FOCIS compliant or compatible simplex or duplex fiber optic adapters and meet or exceed TIA/EIA-568-C.3 requirements.
- B. Fiber adapter panels include horizontal/vertical LC fiber optic adapters.
- C. Fiber optic adapters include zirconia ceramic split sleeves to fit specific network requirements.
- D. LC adapter housing colors follow the TIA/EIA-568-C.3 suggested color identification scheme.
- E. Multimedia modular panels allow customization of installation for applications requiring integration of fiber optic and copper cables.
- F. Blank fiber adapter panels reserve fiber adapter panel space for future use.

- G. All fiber adapter panels snap quickly into the front of fiber optic patch panels and enclosures for easy network deployment or moves, adds, and changes.
- H. Split Sleeve: Zirconia Ceramic
- I. Manufacturer
 - 1. Refer to drawing details for manufacturer and part number.

2.6 FIBER OPTIC PATCH CABLES

- A. Fiber optic patch cords provide interconnect and cross-connect of applications over installations in entrance facilities, telecommunications rooms, data centers and at the desk.
- B. Patch cords support network applications in main, horizontal and equipment distribution areas and are available in riser (OFNR), and low smoke zero halogen (LSZH) rated jacket materials to comply with local cabling ordinances.
- C. Fiber optic patch cords and pigtails are available in OM4, OM3, OM2, OM1, or OS1/OS2 fiber types to meet the demands of Gigabit Ethernet, 10 Gigabit Ethernet and high speed Fibre Channel.
- D. LC Duplex (2-fiber)
- E. OFNR
- F. Field verify length.
- G. Quantity
 - 1. Provide four duplex fiber patch cables for each installed fiber backbone cable.
- H. Manufacturer
 - 1. Refer to drawing details for manufacturer and part number.

2.7 CABLING 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.

2.8 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test multimode optical fiber cables according to TIA-526-14-B and TIA-568-C.3.
- C. Factory test pre-terminated optical fiber cable assemblies according to TIA-526-14-B and TIA-568-C.3.
- D. Cable will be considered defective if it does not pass tests and inspections.

- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method: Utilize cable tray, conduit or J-hook support between Telecommunication Rooms. Utilize cable tray within Telecommunication Room.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 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. Group connecting hardware for cables into separate logical fields.

3.3 FIRESTOPPING

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI ITSIMM, "Firestopping" Chapter.

3.4 GROUNDING

- A. Install grounding according to BICSI ITSIMM, "Grounding (Earthing), Bonding, and Electrical Protection" Chapter.
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.5 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 27 0553 "Identification for Communications Systems."
 - 1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
- B. 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.
- C. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

- D. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA 606-B, for the following:

1. Flexible vinyl or polyester that flexes as cables are bent.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. 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.
 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 3. 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.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. Remove and replace cabling where test results indicate that it does not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 27 1323

SECTION 27 1513.10 – COMMUNICATIONS COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 SUMMARY

- A. Work covered by this Section shall consist of furnishing labor, equipment, supplies, materials, and testing unless otherwise specified, and in performing the following operations recognized as necessary for the installation, termination, and labeling of copper horizontal cabling infrastructure as described on the Drawings and/or required by these specifications.
- B. Section Includes:
 - 1. CAT6 Cable.
 - 2. CAT6A Cable.
 - 3. CAT6 Patch Cables.
 - 4. CAT6A Patch Cables.
 - 5. Termination Hardware
 - 6. Access Control Cable.
 - 7. Labeling.
 - 8. Certification Testing.
 - 9. As-Built Drawings.
 - 10. Grounding provisions for twisted pair cable.
 - 11. Cable Manufacturer Warranty

1.2 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal 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-568.2-D 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.

1.3 ACTION SUBMITTALS

- A. Cabling Manufacturer Certified Installer Certificate
- B. CAT6 Cable

- C. CAT6A Cable
- D. Termination Hardware
- E. CAT6 Patch Cables
- F. CAT6A Patch Cables
- G. Shop Drawings: Reviewed by a current BICSI RCDD.
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
 - 3. Cabling administration Drawings and printouts.
 - 4. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment.
- H. Twisted pair cable testing plan.

1.4 INFORMATIONAL SUBMITTALS

- A. Installer Credentials:
 - 1. Each installer is required to be certified by the manufacturer of the products that are installed (i.e. Panduit, Belden, Hubbell, Commscope)
 - 2. BICSI TECH certification is required for the lead installer that will be onsite at all times.
 - 3. Valid certificates shall be provided to TowerPinkster prior to project kick-off.

1.5 CLOSEOUT SUBMITTALS

- A. Maintenance data.
 - 1. As-built Drawings.
 - 2. Certification results for all installed cables (PDF & Certification tester format)
 - 3. Cabling Manufacturer Warranty Certificate

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer shall have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings, cabling administration Drawings, and field-testing program development by a BICSI TECH.
 - 2. Installation Supervision: Installation shall be under the direct supervision of a BICSI TECH, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as a TECH to supervise on-site testing.
- B. Testing Agency Qualifications: Testing agency is required to have personnel certified by BICSI on staff.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as a TECH.

1.7 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568.1-D, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-E.
- C. Grounding: Comply with TIA-607-D.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 1. Communications Plenum Rated: Type CMP complying with UL 1685.
 2. Communications, Plenum Rated: Type CM, Type CMG, Type CMP, Type CMR, or Type CMX in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. RoHS compliant.

2.3 CAT6 CABLE

- A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6 cable at frequencies up to 350MHz.
- B. Standard Compliances:
 1. ANSI/TIA 568.2-D
 2. NEC/CEC Type CMR (UL 1666) for Non-Plenum
 3. NEC/CEC Type CMP (NFPA 262) for Plenum
 4. UL Listed CMP-LP (0.5A) for Plenum
 5. UL 444
 6. RoHS Compliant Directive 2011/65/EU
 7. ANSI/TIA 862 (Building Automation)
 8. ICEA S-116-732
 9. ICEA S-102-700
 10. ISO/IEC 11801 Ed. 2.0 (Class E)

C. Applications

1. IEEE 802.3: 1000 BASE-T, 100 BASE-TX, 10 BASE-T, PoE, PoE+
2. ANSI/TIA 854: 1000 BASE-TX
3. CDDI, Token Ring, ATM
4. Digital Video
5. Broadband and Baseband Analog Video

D. Conductors: 100-ohm, 23 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP).

F. Refer to drawings for cable manufacturer and part numbers.

2.4 CAT6A CABLE

A. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of Category 6A cable at frequencies up to 500MHz.

B. Standard Compliances:

1. ANSI/TIA 568.2-D
2. NEC/CEC Type CMR (UL 1666) for Non-Plenum
3. NEC/CEC Type CMP (NFPA 262) for Plenum
4. UL Listed CMP-LP (0.6A) for Plenum
5. UL Listed CMR-LP (0.5A) for Non-Plenum
6. UL 444
7. UL 2499
8. RoHS Compliant Directive 2011/65/EU
9. ANSI/TIA 862 (Building Automation)
10. ICEA S-116-732
11. ICEA S-102-700
12. ISO/IEC 11801 Ed. 2.0 (Class EA)

C. Applications

1. IEEE 802.3: 1000 BASE-T, 100 BASE-TX, 10 BASE-T, PoE, PoE+, POE++
2. ANSI/TIA 854: 1000 BASE-TX
3. CDDI, Token Ring, ATM
4. Digital Video
5. Broadband and Baseband Analog Video

D. Conductors: 100-ohm, 23 AWG solid copper.

E. Shielding/Screening: Unshielded twisted pairs (UTP).

F. Refer to drawings for cable manufacturer and part numbers.

2.5 CAT6 PATCH CABLES

- A. Description: Patch cord cable shall be offered in multiple colored UTP cable for design flexibility with a clear strain relief boot on each modular plug.
1. CAT6/Class E
 2. Compatible with both T568A and T568B wiring schemes
 3. Exceeds all ANSI/TIA-568.2-D and ISO 11801 Class E standards for all frequencies from 1 to 250 MHz
 4. Meets ANSI/TIA-1096-A (formerly FCC Part 68); contacts plated with 50 microinches of gold for superior performance
 5. UL 1863 approved
 6. A variety of lengths shall be available for design flexibility.
 7. PoE compliance: Rated for 2500 cycles with IEEE 802.3af / 802.3at and 802.3bt type 3 and type 4
 8. Rated to 2500 mating cycles.
 9. Field terminated patch cables shall not be allowed in any situation.
 10. Refer to drawings for manufacturer and part numbers.

2.6 CAT6A PATCH CABLES

- A. Description: Patch cord cable shall be offered in multiple colored UTP cable for design flexibility with a clear strain relief boot on each modular plug.
1. CAT6A/Class EA
 2. Compatible with both T568A and T568B wiring schemes
 3. Exceeds all ANSI/TIA-568.2-D and ISO 11801 Class EA standards for all frequencies from 1 to 500 MHz
 4. Meets ANSI/TIA-1096-A (formerly FCC Part 68); contacts plated with 50 microinches of gold for superior performance
 5. UL 1863 approved
 6. A variety of lengths shall be available for design flexibility.
 7. PoE compliance: Rated for 2500 cycles with IEEE 802.3af / 802.3at and 802.3bt type 3 and type 4
 8. Rated to 2500 mating cycles.
 9. Field terminated patch cables shall not be allowed in any situation.
 10. Refer to drawings for manufacturer and part numbers.

2.7 TERMINATION HARDWARE

- A. Description: This section covers patch panels, jack modules, modular plugs, faceplates and surface mount boxes.
- B. Patch Panels
1. Mounts to standard EIA 19" rack
 2. All metal modular patch panels.
 3. Stainless steel, painted black
 4. Accept shielded and non-shielded jacks.
 5. Write-on areas and option adhesive labels for port identification.
 6. 24 and 48 port.

7. Flat and angled design.
8. Refer to drawings for manufacturer and part numbers.

C. Jack Modules

1. Category rating equal to attached cable, 8-position
2. Meets ANSI/TIA-1096-A contacts plated with 50 microinches of gold for superior performance
3. Rated for 2500 cycles with IEEE 802.3af / 802.3at and 802.3bt type 3 and type 4. Supports Power over HDBaseT up to 100 watts
4. Operating Temp: -10°C to 65°C (14°F to 149°F)
5. Terminate 4-pair, 22-26 AWG
6. 100 Ohm
7. Several available color options
8. Refer to drawings for manufacturer and part numbers.

D. Modular Plugs

1. Category rating equal to attached cable, 8-position/8 wire
2. Terminate 23-24 AWG (solid or stranded)
3. 100 Ohm
4. Supports PoE, PoE+, and proposed Type 3 and 4 PoE++ applications for up to 100 W
5. Refer to drawings for manufacturer and part numbers.

E. Faceplates - Plastic

1. Available in 1, 2, 3, 4 and 6 port single-gang
2. Optional label windows
3. Accepts variety of Category jacks and AV inserts
4. Refer to drawings for manufacturer and part numbers.

F. Faceplates – Stainless Steel

1. Available in 2, 4 and 6 port single-gang
2. Optional label windows
3. Accepts variety of Category jacks and AV inserts
4. Refer to drawings for manufacturer and part numbers.

G. Surface Mount Boxes

1. Low profile design
2. Variety of port densities
3. Accepts variety of Category jacks and AV inserts
4. Breakouts for use with surface raceway
5. Made of ABS
6. UL 1863 rated
7. Refer to drawings for manufacturer and part numbers.

2.8 ACCESS CONTROL CABLE

A. Composite Cable

1. Description: The cable shall be a composite cable that addresses the connectivity for all primary access control components such as card readers, door contacts, REX and locking devices.
 - a. Cable shall be plenum rated.
 - b. Composite cable shall have the following:
 - 1) 3 pair, 22 AWG – card reader
 - 2) 4 conductor, 18 AWG – lock device
 - 3) 4 conductor, 22 AWG – REX
 - 4) 2 conductor, 22 AWG – door contact
 - c. All conductors shall be stranded bare copper with Flamarrest® insulation.
2. Standards and Compliance
 - a. Environmental Suitability: Indoor - Plenum, Indoor
 - b. Sustainability: Product Lens™, Environmental Product Declaration (EPD) Available
 - c. Flammability / Fire Resistance: NFPA 262, FT6, FT6, IEC 60332-1-2
 - d. NEC / UL Compliance: Article 800, CMP
 - e. CEC / C(UL) Compliance: CMP
 - f. CPR Euroclass: Eca
 - g. European Directive Compliance: EU CE Mark, EU Directive 2015/863/EU, EU Directive 2011/65/EU (ROHS II), EU Directive 2012/19/EU (WEEE)
 - h. APAC Compliance: China RoHS II (GB/T 26572-2011)
 - i. Non-Plenum Number: 558AFJ
3. Refer to drawings for manufacturer and part numbers.

B. Door Contact Cable

1. Description: Security, Pro Audio & Intercom Cable, 2 Conductor 18 AWG stranded (7x26) bare copper conductors with FEP insulation, Beldfoil® shield, Plenum, Flamarrest® jacket with ripcord.
2. Cable shall be plenum rated.
3. Refer to drawings for manufacturer and part numbers.

C. REX & Push-Button Control Cable

1. Description: Security & Sound Cable, 4-18 AWG stranded bare copper conductors with polypropylene insulation, Beldfoil® shield and PVC jacket with ripcord.
2. Cable shall be plenum rated.
3. Refer to drawings for manufacturer and part numbers.

D. Card Reader Cable

1. Description: Security & Sound Cable, 6-18 AWG stranded bare copper conductors with Flamarrest® insulation, Beldfoil® shield and Flamarrest® jacket with ripcord.
2. Cable shall be plenum rated.
3. Refer to drawings for manufacturer and part numbers.

2.9 LABELING

- A. Description: 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.
2. All labels shall be installed on each end of installed cable within 12 inches of termination.
3. Labels shall be:
 - a. Self-laminating vinyl labels
 - b. Permanent acrylic tape that adheres to surfaces that are smooth, rough or powder coated
 - c. Machine-printed labels indicating:
 - 1) Telecommunication Room
 - 2) Patch Panel
 - 3) Patch panel port
4. Hand-Written labels shall **NOT** be allowed in any situation.

2.10 AS-BUILT DRAWINGS

- A. Description: Drawings submitted by contractor upon completion of project reflecting all changes made and documenting all installations.
 1. As-built drawings shall be submitted to TowerPinkster for any/all structured cabling projects.
 2. Each as-built shall indicate locations of all installed cables.
 3. As-built drawing shall only have typed text (No hand-written as-builts).
 4. As-builts shall be submitted in PDF format.
 - a. Any other format requires approval prior to submittal.

2.11 GROUNDING PROVISIONS FOR TWISTED PAIR CABLING

- A. Comply with requirements in Section 27 0526 "Grounding and Bonding for Communications Systems" for grounding conductors and connectors.
- B. Comply with TIA-607-D.

2.12 CABLE MANUFACTURER WARRANTY

- A. A cabling manufacturer warranty shall be provided by the installation contractor for all structured cabling projects.
 1. Warranty shall be 25-year standards-based performance warranty that applies to all registered links and/or channels in an installation.
 2. Warranty shall be submitted within 30 days of project completion.

PART 3 - EXECUTION

3.1 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.

- B. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.
1. Install plenum cable in environmental air spaces, including plenum ceilings.
 2. Comply with requirements for raceways and boxes specified in Section 27 0528 "Pathways for Communications Systems."
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.
- D. General Requirements for Cabling:
1. Comply with TIA-568.2-D.
 2. Comply with BICSI's Information Transport Systems Installation Methods Manual, 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. 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.
 7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
 8. 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.
 9. 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.
 10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 11. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
 12. 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.
 13. Provide 5ft service loop at each location (security cameras & wireless access points shall have 15ft)
 14. Bundle CAT6 cables in groups of no more than 24 cables as they route on ladder rack to patch panel in all exposed areas of Telecommunication Rooms.
- 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.

3.2 FIRESTOPPING

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.3 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-D and NECA/BICSI-607.
- C. 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.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- 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-568.2-D.
 - 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.
- 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. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION 27 1513

SECTION 27 1700 – TESTING AND ADMINISTRATION OF BALANCED TWISTED PAIR INFRASTRUCTURE

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.
- B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.
- C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge

1.2 SCOPE

- A. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.
- B. This Section includes minimum requirements for:
 - 1. Copper cabling test instruments.
 - 2. Copper cabling testing.
 - 3. Identification
 - a. Labels and labeling.
 - 4. Administration
 - a. Test results documentation.
 - b. As-built drawings.
- C. Testing shall be carried out in accordance with this document.
- D. Testing shall be performed on each cabling link. (100% testing)
- E. All tests shall be documented.

1.3 QUALITY ASSURANCE

- A. All testing procedures and field-test instruments shall comply with applicable requirements of:
 - 1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
 - 2. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
 - 3. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
 - 4. ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.

5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.
- B. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
 1. Manufacturer of the connectors or cable.
 2. Manufacturer of the test equipment used for the field certification.
 3. Training organizations (e.g., BICSI, A Telecommunications Association headquarters in Tampa, Florida)
- C. The Owner or the Owner's representative shall be invited to witness and/or review field-testing.
 1. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
 2. The Owner or the Owner's representative will select a random sample of 5% of the installed links. The Owner or the Owner's representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.4 SUBMITTALS

- A. Manufacturers catalog sheets and specifications for the test equipment.
- B. A schedule (list) of all balanced twisted-pair copper links to be tested.
- C. Sample test reports.

1.5 ACCEPTANCE OF TEST RESULTS

- A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in tested for:
 1. Wire Map
 2. Length
 3. Propagation Delay
 4. Delay Skew.
 5. DC Loop Resistance – recorded for information only
 6. DC Resistance Unbalance – recorded for information only
 7. Insertion Loss
 8. NEXT (Near-End Crosstalk)
 9. PS NEXT (Power Sum Near-End Crosstalk)
 10. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
 11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
 12. ACR-F (Attenuation to Crosstalk Ratio Far-End)

13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
14. Return Loss
15. TCL (Transverse Conversion Loss) – recorded for information only
16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only

- B. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in Part 3. Any Permanent Link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements. The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with Part 3.
- C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

1.6 PART 2 - PRODUCTS

1.7 BALANCED TWISTED-PAIR CABLE TESTERS

- A. A The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.
- B. Certification tester
 1. Accuracy
 - a. Level III accuracy in accordance with ANSI/TIA-1152
 - b. Independent verification of accuracy
 - c. Acceptable manufacturers
 - 1) Fluke Networks or Ideal Networks
 2. Permanent Link Adapters
 - a. RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C
 - b. Twisted pair Category 5e, 6, 6A, 7 or 7_A cords are not permitted as their performance degrades with use and can cause false Return Loss failures
 3. Results Storage
 - a. Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below
 4. Measurement capabilities
 - a. Wire Map
 - b. Length
 - c. Propagation Delay
 - d. Delay Skew
 - e. DC Loop Resistance
 - f. DC Resistance Unbalance
 - g. Insertion Loss
 - h. NEXT (Near-End Crosstalk)
 - i. PS NEXT (Power Sum Near-End Crosstalk)
 - j. ACR-N (Attenuation to Crosstalk Ratio Near-End)

- k. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
- l. ACR-F (Attenuation to Crosstalk Ratio Far-End)
- m. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
- n. Return Loss
- o. TCL (Transverse Conversion Loss)
- p. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
- q. Time Domain Reflectometer
- r. Time Domain Xtalk Analyzer

C. PC Software

- 1. Windows® based.
- 2. Must show when 3 dB and 4 dB rules are applied
- 3. Re-certification capability, where results must have their Cable IDs suffixed with (RC).
- 4. Built in PDF export – no additional third-party software permitted.
- 5. Built-in statistical analysis.

1.8 IDENTIFICATION

A. Labels

- 1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
- 2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
- 3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
- 4. Where insert type labels are used provide clear plastic cover over label.
- 5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18” above all direct buried services, underground conduits and duct-banks.
- 6. Acceptable Manufacturers:
 - a. Brady Corporation
 - b. Silver Fox
 - c. Brother
 - d. Epson
 - e. Dymo

1.9 ADMINISTRATION

- A. Administration of the documentation shall include test results of each Permanent Link.
- B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
- C. The test result records saved within the field-test instrument shall be transferred into a Windows® -based database utility that allows for the maintenance, inspection and archiving of these test records.
- D. Each individual test result shall be saved with the same name as the cable identification label installed in field.

- E. All test results shall be provided in PDF & original certification tester format within 5 business days of project completion.

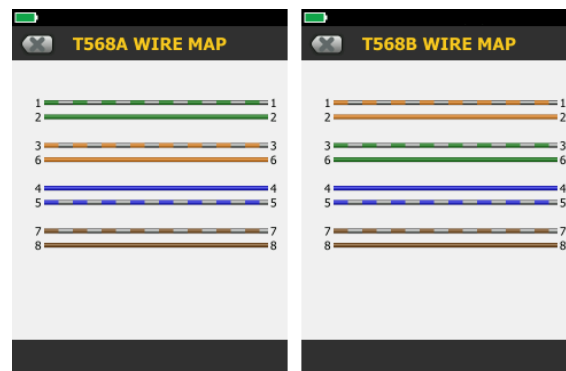
PART 3 - EXECUTION

1.10 GENERAL

- A. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 BALANCED TWISTED PAIR CABLE TESTING

- B. Field-test instruments shall have the latest software and firmware installed.
- C. Permanent Link test results including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.
- D. Testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.
- E. Permanent Link adapters made from twisted pair Category 6 cords are not permitted as their performance degrades with use and can cause false Return Loss failures.
- F. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6 Permanent Link test each day to ensure no degradation of the tester or its Permanent Link adapters.
- G. Wire Map Measurement
 - 1. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
 - a. Continuity to the remote end
 - b. Shorts between any two or more conductors
 - c. Reversed pairs
 - d. Split pairs
 - e. Transposed pairs
 - f. Distance to open on shield
 - g. Any other miss-wiring
 - 2. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used. Examples are given below:



3.

H. Length Measurement

1. The length of each balanced twisted pair shall be recorded.
2. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
3. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

I. Propagation Delay measurement

1. Is the time it takes for a signal to reach the end of the link.
2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
3. The propagation delay of each balanced twisted pair shall be recorded.
4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

J. Delay Skew measurement

1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
2. The delay skew of each balanced twisted pair shall be recorded.
3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

K. DC Resistance

1. Often reported as Resistance, is the loop resistance of both conductors in the pair.
2. Is not specified in ANSI/TIA-1152 but shall be recorded for all four pairs.

L. DC Resistance Unbalance

1. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.
2. Is not specified in ANSI/TIA-1152 for a Permanent Link but shall be recorded for all four pairs.

M. Insertion Loss

1. Is the loss of signal strength over the cabling (in dB).
2. The frequency resolution shall be:

- a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
3. Worst case shall be reported for all four pairs in one direction only.
 4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
 5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

N. NEXT (Near-End Crosstalk)

1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (12 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

O. PS NEXT (Power Sum Near-End Crosstalk)

1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

P. ACR-N (Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
3. Shall be calculated in both directions.
4. Is not specified in ANSI/TIA-1152 but shall be recorded for all 12 possible combinations.

- Q. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)
1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
 2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 3. Shall be calculated in both directions.
 4. Is not specified in ANSI/TIA-1152 but shall be recorded for all 8 possible combinations.
- R. ACR-F (Attenuation Crosstalk Ratio Far-End)
1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
 2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 3. Shall be measured in both directions. (24 pair to pair possible combinations)
 4. Both worst case and worst margins shall be reported.
 5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.
 6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- S. PS ACR-F (Power Sum Attenuation Crosstalk Ratio Far-End)
1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
 2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 3. Shall be measured in both directions. (8 pair possible combinations)
 4. Both worst case and worst margins shall be reported.
 5. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
 6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
- T. Return Loss
1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
 2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 3. Shall be measured in both directions. (8 pair possible combinations)
 4. Both worst case and worst margins shall be reported.
 5. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.

6. Is not to exceed the Category 6 Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
7. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
8. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

U. TCL (Transverse Conversion Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

V. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link but shall be recorded for all 8 possible combinations.

1.11 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., "as saved in the field-test instrument". The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
2. The test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.
3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD or DVD prior to Owner acceptance of the building. This CD or DVD shall include the software tools required to view, inspect, and print any selection of the test reports.

4. Circuit IDs reported by the test instrument should match the specified label ID (see **Error! Reference source not found.** of this Section).
 5. The detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information
 - a. The overall Pass/Fail evaluation of the link-under-test
 - b. The date and time the test results were saved in the memory of the tester
 - c. The identification of the customer site as specified by the end-user
 - d. The name of the test limit selected to execute the stored test results
 - e. The name of the personnel performing the test
 - f. The version of the test software and the version of the test limit database held within the test instrument
 - g. The manufacturer, model and serial number of the field-test instrument
 - h. The adapters used
 - i. The factory calibration date
 - j. Wire Map
 - k. Propagation Delay values, for all four pairs
 - l. Delay Skew values, for all four pairs
 - m. DC Resistance values, for all four pairs
 - n. DC Resistance Unbalance, values for all four pairs
 - o. Insertion Loss, worst case values for all four pairs
 - p. NEXT, worst case margin and worst case values, both directions
 - q. PS NEXT, worst case margin and worst case values, both directions
 - r. ACR-F, worst case margin and worst case values, both directions
 - s. PS ACR-F, worst case margin and worst case values, both directions
 - t. Return Loss, worst case margin and worst case values, both directions
 - u. TCL, worst case values both directions
 - v. ELTCTL, worst case values, both directions.
 - w. Time Domain Crosstalk data if the link is marginal or fails
 - x. Time Domain Reflectometer data if the link is marginal or fails
- B. Record copy and as-built drawings
1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on a CD or DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-builts shall include all field changes made up to construction completion:
 - a. Field directed changes to pull schedule.
 - b. Horizontal cable routing changes.
 - c. Associated detail drawings.

END OF SECTION 27 1700

SECTION 27 1800 - TESTING, IDENTIFICATION AND ADMINISTRATION OF FIBER INFRASTRUCTURE

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.
- B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.
- C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

1.2 SCOPE

- A. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fiber cabling.
- B. This Section includes minimum requirements for:
 - 1. Fiber optic test instruments.
 - 2. Fiber optic testing.
 - 3. Identification
 - a. Labels and labeling.
 - 4. Administration
 - a. Test results documentation.
 - b. As-built drawings.
- C. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR). The condition of the fiber end faces shall also be verified.
- D. Testing shall be performed on each cabling link (connector to connector).
- E. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.
 - 1. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
- F. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps.

1. Optionally, documentation shall also include optical length measurements and pictures of the connector end face.

1.3 QUALITY ASSURANCE

- A. All testing procedures and field-test instruments shall comply with applicable requirements of:
 1. ANSI Z136.2, ANSI For Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources
 2. ANSI/TIA-526-14-C, Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant with full OTDR descriptions
 3. ANSI/TIA-526-7-A, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
 4. TIA-TSB-4979, Practical Considerations for Implementation of Multimode Launch Conditions in the Field
 5. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
 6. ANSI/TIA-568.3-D, Optical Fiber Cabling and Components Standard
 7. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements
- B. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
 1. Manufacturer of the fiber optic cable and/or the fiber optic connectors.
 2. Manufacturer of the test equipment used for the field certification or representative.
 3. Training organization e.g. BICSI
- C. The Owner or the Owner's representative shall be invited to witness and/or review field-testing.
 1. The Owner or the Owner's representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
 2. The Owner or the Owner's representative will select a random sample of 5% of the installed links. The Owner or the Owner's representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.4 SUBMITTALS

- A. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and video microscope.
- B. A schedule (list) of all optical fibers to be tested.
- C. Sample test reports.

1.5 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:

1. Optical loss testing

a. Multimode and Singlemode links

1) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568.3-D.

a) $\text{Link Attenuation (dB)} = \text{Cable_Attn (dB)} + \text{Connector_Attn (dB)} + \text{Splice_Attn (dB)}$

b) $\text{Cable_Attn (dB)} = \text{Attenuation Coefficient (dB/km)} * \text{Length (Km)}$

c) $\text{Connector_Attn (dB)} = \text{number of connector pairs} * \text{connector loss (dB)}$

d) Maximum allowable connector loss = 0.75 dB
Check your application limits, you may need to reduce the allowable connector loss here

e) Use of Reference Grade connectors in Test Reference Cords.

f) *Test Reference Cords shall use Reference Grade connectors and the mated loss budget value (first and last) for these cords for Multimode shall be 0.30 dB and for Single-Mode shall be 0.50 dB.*

g) $\text{Splice_Attn (dB)} = \text{number_of_splices} * \text{splice loss (dB)}$

h) Maximum allowable splice loss = 0.3 dB
Check your application limits, you may need to reduce the allowable connector loss here

i) The values for the Attenuation Coefficient (dB/km) are listed in the table below: Your cable may perform better than this, check the datasheet from the vendor and insert values here if desired

Type of Optical Fiber	Wavelength (nm)	Attenuation coefficient (dB/km)	Wavelength (nm)	Attenuation coefficient (dB/km)
Multimode 62.5/125 μm	850	3.5	1300	1.5
Multimode 50/125 μm	850	3.0	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2.

1) OTDR testing

a) Reflective events (connections) shall not exceed: Check your application limits, you may need to reduce the allowable connector loss/reflectance here

b) 0.75 dB in optical loss when bi-directionally averaged

c) -35 dB Reflectance for multimode connections

d) -40 dB reflectance for UPC singlemode connections

e) -55 dB reflectance for APC singlemode connections

f) Non-reflective events (splices) shall not exceed 0.3 dB.
Check your application limits, you may need to reduce the allowable splice loss here

- 2) Magnified end face inspection
 - a) Fiber connections shall be visually inspected to IEC 61300-3-35 Edition 1.0 for end face quality.
 - b) Scratched, pitted or dirty connectors shall be diagnosed and corrected.
 - b. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 3.
 - c. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.
 - d. Note: High Bandwidth applications such as 10GBASE-SR, FC1200, and 40GBASE-SR4 impose stringent channel loss limits. Where practical, certification should consider loss length limits that
 - e. meet maximum channel (transmitter to receiver) loss. 0.75 dB per connector pair loss may not support the intended application.
3. Performance specification for multimode fiber links at 850 nm.
 - 4.

Fiber Type		Band- width	10GBASE-SR		FibreChannel 1200- MX-SN-I		40GBASE-SR4	
	μm	(MHz• Km)	Length (m)	Loss (dB)	Length (m)	Loss (dB)	Length (m)	Loss (dB)
OM 1	62.5	200	33	2.5	33	2.4	N/A	N/A
OM 2	50	500	82	2.3	82	2.2	N/A	N/A
OM 3	50	2000	300	2.6	300	2.6	100	1.9
OM 4	50	4700	400	2.9	N/A	N/A	150	1.5
OM 5	50	4700	400	2.9	N/A	N/A	150	1.5

- B.
- C. PART 2 – PRODUCTS
- D. OPTICAL FIBER CABLE TESTERS
- E. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.
- F. Optical loss test set (OLTS)
 1. Singlemode optical fiber light source
 - a. Provide dual laser light sources with central wavelengths of 1310 nm (± 20 nm) and 1550 nm (± 20 nm).

- b. Output power of -10 dBm minimum.
 - c. The test reference cords must demonstrate an insertion loss ≤ 0.25 dB when mated against each other, and this test shall be stored and delivered with the other test results.
 - d. Acceptable manufacturers
 - 1) Fluke Networks or Ideal Networks
 - 2. Power Meter
 - a. Provide 850 nm, 1300 nm, 1310 nm, and 1550 nm wavelength test capability.
 - b. Power measurement uncertainty of ± 0.25 dB.
 - c. Store reference power measurements.
 - d. Save at least 10,000 results to internal memory.
 - e. PC interface (USB).
 - f. Acceptable manufacturers
 - 1) Fluke Networks or Ideal Networks
- G. Optical Time Domain Reflectometer (OTDR)
 - 1. Shall have a bright, color LCD display with backlight.
 - 2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
 - 3. Weight with battery and module of not more than 4.5 lb. and volume of not more than 200 in³.
 - 4. Internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally tested fiber links.
 - 5. USB port to transfer data to a PC or thumb drive/memory stick.
 - 6. Singlemode OTDR
 - a. Wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm).
 - b. Event dead zones not to exceed 0.6 m at 1310 nm and 1550 nm.
 - c. Attenuation dead zones not to exceed 3.7 m at 1310 nm and 1550 nm.
 - d. Distance range not less than 80 km at 1310 nm and 130 km at 1550 nm.
 - e. Dynamic range at least 32 dB for 1310 nm and 30 dB at 1550 nm.
 - f. Allow bi-directional testing without moving the OTDR to the far end.
 - g. Perform on-board bi-directional averaging.
 - 7. Acceptable manufacturers
 - 1) Fluke Networks or Ideal Networks
- H. Fiber Microscope
 - 1. Field of view 420 μ m x 320 μ m
 - a. Video camera systems are preferred.
 - b. Camera probe tips that permit inspection through adapters are required.
 - c. Test equipment shall be capable of saving and reporting the end face image to IEC 613003-3-35.
 - 2. Acceptable manufacturers
 - 1) Fluke Networks or Ideal Networks
- I. Integrated OLTS, OTDR and fiber microscope
 - 1. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.
 - 2. Acceptable manufacturers

- a. Fluke Networks or Ideal Networks

2.2 IDENTIFICATION

J. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear "tail" that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
4. Where insert type labels are used provide clear plastic cover over label.
5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18" above all direct buried services, underground conduits and duct-banks.
6. Acceptable Manufacturers:
 - a. Panduit
 - b. Silver Fox
 - c. W.H. Brady
 - d. d-Tools
 - e. Brother
 - f. Dymo
 - g. Epson

1.6 ADMINISTRATION

- A. Administration of the documentation shall include test results of each fiber link and channel.
- B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
- C. The test result records saved within the field-test instrument shall be transferred into a Windows™-based and/or cloud-based database utility that allows for the maintenance, inspection and archiving of these test records.
- D. Each individual test result shall be saved with the same name as the cable identification label installed in field.
- E. All test results shall be provided in PDF & original certification tester format within 5 business days of project completion.
- F.

PART 3 – EXECUTION

3.1 GENERAL

- G. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.
- H. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 OPTICAL FIBER CABLE TESTING

- I. Field-test instruments shall have the latest software and firmware installed.
- J. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC and/or a cloud-based service in which the administrative documentation (reports) may be generated.
- K. Fiber end faces shall be inspected using a video scope with a field of view not less than 425 μm x 320 μm .
 - 1. It is preferable that the end face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.
- L. Testing shall be performed on each cabling segment (connector to connector).
- M. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.
- N. Testing of the cabling shall be performed using high-quality test reference cords of the same core size as the cabling under test, terminated with reference grade connectors. Reference grade connectors are defined as having a loss not exceeding 0.1 dB for multimode and 0.2 dB for singlemode. The test reference cords for OLTS testing shall be between 2 m and 5 m in length. The length of the launch and tail fibers for multimode OTDR testing shall be at least 100 m (328 ft.). For singlemode, the length of the launch and tail fibers will depend on the link under test. As a guide, the following table can be used for determining the length of the launch and tail fibers.

Maximum Length of Link (km)		Typical Pulse Width (ns)	Minimum Launch and Tail Cord Length (m)
1310 nm	1550 nm only		
0 to 35	0 to 50	$\leq 1,000$	130
35 to 45	50 to 65	3,000	400
45 to 50	65 to 75	10,000	1,000
≥ 50	≥ 75	20,000	2400

- O. Optical loss testing
 - 1. Horizontal/Backbone link
 - a. Multimode links shall be tested in one direction at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-C, one-cord reference method, with an Encircled Flux compliant launch.
 - b. Singlemode backbone links shall be tested in one direction at 1310 nm and 1550 nm in accordance with ANSI/TIA-526-7-A, Method A.1 (One-cord reference method).
 - c. Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
- P. OTDR Testing

1. Fiber links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.
 - a. Multimode: 850 nm and 1300 nm.
 - b. Singlemode: 1310 nm and 1550 nm.
2. Each fiber link and channel shall be tested in both directions.
 - a. The launch and tail fibers shall remain in place for the measurement in the opposite direction – failing to do so will result in an increase in measurement uncertainty.
 - b. The use of a loop back fiber at the far end with a tail fiber at the near end on the adjacent fiber is permitted for bi-directional testing, so long as the OTDR is able to split the trace automatically into two traces for the two fibers under test.
3. A launch cable shall be installed between the OTDR and the first link connection.
4. A tail cable shall be installed after the last link connection.

Q. Magnified End Face Inspection

1. Fibers shall be inspected using a video scope with a minimum field of view 425 µm x 320 µm to IEC 61300-3-35 Edition 1.0. The following test limits shall be used:
 - a. Multimode connectors; Table 6 of IEC 61300-3-35 Edition 1.0
 - b. Singlemode field polished connectors; Table 5 of IEC 61300-3-35 Edition 1.0
 - c. Singlemode factory polished connectors; Table 3 of IEC 61300-3-35 Edition 1.0
 - d. Angled Physical Contact (APC) connectors; Table 4 of IEC 61300-3-35 Edition 1.0

R. Length Measurement

1. The length of each fiber shall be recorded.
2. It is preferable that the optical length be measured using an OLTS or OTDR.

S. Polarity Testing

1. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA-568.3-D. The polarity of the paired duplex fibers shall be verified using an OLTS.

3.3 IDENTIFICATION

T. Labeling

1. Labeling shall conform to the requirements specified within ANSI/TIA-606-B or to the requirements specified by the Owner or the Owner's representative.

3.4 ADMINISTRATION

U. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based and/or cloud-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC or cloud unaltered, i.e., “as saved in the field-test instrument”. The following formats do not provide adequate protection of these records and shall not be used.

- a. Portable document format (PDF)
 - b. Word (.doc & .docx)
 - c. Comma separated values (.csv)
 - d. Excel separated values (.xls & .xlsx)
 - e. Text (.txt)
2. The test results documentation shall be available for inspection by the Owner or the Owner's representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.
3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered in an electronic format or, preferably through a cloud-based service, prior to Owner acceptance of the building in the original format used by the cabling vendors' software.
4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).
5. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information
 - a. The identification of the customer site as specified by the end-user.
 - b. The name of the test limit selected to execute the stored test results.
 - c. The name of the personnel performing the test.
 - d. The date and time the test results were saved in the memory of the tester.
 - e. The manufacturer, model and serial number of the field-test instrument.
 - f. The version of the test software and the version of the test limit database held within the test instrument.
 - g. The fiber identification number.
 - h. The length for each optical fiber.
 - i. The index of refraction used for length calculation when using length capable OLTS.
 - j. The backscatter coefficient of the fiber under test when using an OTDR.
 - k. Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).
 - l. Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.
 - m. The length for each optical fiber as calculated by the OTDR.
 - n. The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements
 - o. Optional
 - 1) A picture or image of each fiber end-face
 - 2) A pass/fail status of the end-face using IEC 61300-3-35 Edition 1.0

V. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on CD/DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. CAD drawings are to incorporate test data imported from the test instruments.
2. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-built shall include all field changes made up to construction completion:
 - a. Field directed changes to pull schedule.

- b. Field directed changes to cross connect and patching schedule.
- c. Horizontal cable routing changes.
- d. Backbone cable routing or location changes.
- e. Associated detail drawings.

W.

END OF SECTION 27 1800

SECTION 27 4116 – INTEGRATED AUDIO VIDEO SYSTEMS AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY OF WORK

- A. Work includes the following, as described in this Specification document, associated project drawings and any subsequent addenda:

1. Existing technology demolition work
2. Provision of professional systems engineering and programming services.
3. Provision of accurate and timely project management, including, but not limited to:
 - a. Implementation scheduling
 - b. Coordination with Owner, Construction Manager, Technology Consultant and other trades
 - c. Problem identification and resolution
 - d. Installation coordination at site(s)
 - e. Configuration and programming coordination
 - f. Coordination of testing
 - g. Coordination of Owner orientation
 - h. Assembly and delivery of project documentation
 - i. Accurate and timely delivery of administrative documentation
 - 1) Project schedules
 - 2) Project status reports
 - 3) Pay applications
 - 4) Other as requested
4. Receipt and storage of all equipment on behalf of the Owner.
5. Transportation of all equipment to designated locations.
6. Provision of complete and fully functional audio video systems.
7. Provision of complete trash removal and recycling services.
8. Provision of complete project documentation.
9. Provision of product orientation services.

1.2 RELATED DOCUMENTS

- A. Project drawings

1.3 STANDARDS & GUIDELINES

1. Audiovisual design and installation practices shall comply with the following standards issued by AVIXA (Audiovisual and Integrated Experience Association) and ANSI/INFOCOMM
2. INFOCOMM 2014 - AV/IT Infrastructure Guidelines for Higher Education.
3. AVIXA A102.01:2017 - Audio Coverage Uniformity in Listener Areas.
4. AVIXA F501.01:2015 - Cable Labeling for Audiovisual Systems.
5. AVIXA V202.01:2016 - Display Image Size for 2D Content in Audiovisual Systems.
6. ANSI-J-STD-710 - 2015 - Audio, Video and Control Architectural Drawing Symbols

7. ANSI/INFOCOMM 2M-2010 - Standard Guide for Audiovisual Systems Design and Coordination processes.
8. ANSI/INFOCOMM 3M-2011 - Projected Image System Contrast Ratio
9. ANSI/INFOCOMM 4:2012 - Audiovisual Systems Energy Management.
10. ANSI/INFOCOMM 10:2013 - Audiovisual Systems Performance Verifications.

1.4 ACTION SUBMITTALS

- A. Product Data: Submit applicable product information sheets for all products. Information sheets that include details for multiple model numbers, Contractor shall circle, or otherwise highlight, the applicable model number, color, other defining characteristic for the product being supplied.
 1. Video display equipment (electronics, mounts and screens)
 2. Enclosures/furniture (racks, enclosures, podiums)
 3. Control system equipment (processors/user interfaces)
 4. Audio system (amplifiers, mixers, speakers, microphones, antennas)
 5. AV signal routing equipment (switchers, distribution amplifiers, transmitters, receivers)
 6. I/O connection interface equipment (wallplate and floor box hardware)
 7. Ethernet equipment (AV related)
 8. Video conference equipment (codec, camera, interfacing)
 9. Source equipment (AV sources)
 10. All cabling & termination hardware
- B. Installer Certifications: Submit manufacturer training certifications for installers.
 1. 1. Atlona Level 100: Atlona Technology Specialist
- C. 2. Atlona Level 200: Atlona Certified Technologist Shop Drawings: Submit assembly and installation layout drawings showing product components in assembly with adjacent materials and products (speakers, panels, microphones, electronics rack, enclosure, etc.).
- D. Operation and Maintenance Data.
 1. Not applicable
- E. Warranty: Submit manufacturer's standard warranty statement. Submit Contractor statement of project warranty.

1.5 APPROVED PRODUCTS

- A. Certain products, detailed in the project drawings, are specified by manufacturer and model number. These products shall be included in base bid proposals. Voluntary alternates shall be considered but are to be submitted as a separate proposal (i.e. -not as part of base bid submittal). Alternate solutions will not be pre-evaluated or pre-approved.
- B. Audio Video system-type designation symbols are defined on technology floorplans and detail sheets of the project drawings. Audio Video systems are designated as system types. System types are designated as AV[#]. Each AV System Type has a detailed riser diagram, included in the project drawings of this bid package, which indicates required major hardware and cabling for the system. Detailed manufacturer and part number is detailed on a AV System Product Key. Refer to project drawings.

1.6 AUDIO VIDEO SYSTEM DEFINITION & DETAIL

- A. Project drawings include detail to indicate intended device locations and intended signal flow/functionality.
- B. Contractor is responsible for including any/all devices, cables, adapters and accessories to provide complete and functional systems. Project drawings include riser diagrams, notes and details to indicate the intended signal flow and overall functionality. The Contractor shall supply all needed parts for functional systems, regardless of whether all parts are indicated on project drawings.

1.7 OVERALL PROJECT OVERVIEW

- A. This project consists of the installation of new AV systems. Detailed technology floorplans are provided as part of the project drawings. Unless otherwise noted, the Contractor shall provide all technology hardware. Certain system types have various "Owner Furnished Equipment". This equipment shall be provided by the Owner, to the Contractor. Contractor shall install this equipment.

1.8 QUALITY ASSURANCE:

- A. Manufacturer Qualifications: Minimum 5 years' experience in manufacture of similar products in use in similar environments, including project size, and complexity, and with the production capacity to meet the construction and installation schedule.
- B. Installer Qualifications: Installation, disassembly, re-assembly and calibration shall be done by manufacturer-trained and certified installation technicians. Assigned site Project Manager (Site Foreman) shall have a minimum of 5 years' experience managing/supervising projects of similar size and complexity.

C. MATERIALS

- 1. Source Limitations: Obtain components and accessories direct from manufacturer or manufacturer-authorized distributor. Sourced product shall carry full manufacturer warranty support.
- 2. All supplied products must be new. Remanufactured or refurbished product shall not be utilized.
- 3. All supplied products must be new. Remanufactured or refurbished product shall not be utilized.
- 4. Electrical Components: Listed and labeled per NFPA 70, Article 100 by a testing agency acceptable to authorities having jurisdiction.

D. STANDARDS COMPLIANCE

- 1. Comply with the latest edition, revision or current guideline of each standard code (or best practice) as published by the following entities:
 - a. American Institute of Architects (AIA)
 - b. American National Standard Institute (ANSI)
 - c. American Society for Testing and Materials (ASTM)
 - d. Audiovisual and Integrated Experience Association (AVIXA)
 - e. Building Industry Consulting Service International (BICSI)
 - f. Electronics Industries Association (EIA)
 - g. Federal Communications Commission (FCC)
 - h. Federal Information Processing Standards (FIPS)
 - i. HDBaseT Alliance (HDBaseT)
 - j. Institute of Electrical and Electronics Engineers (IEEE)

- k. National Electrical Manufacturers Association (NEMA)
- l. National Fire Protection Association (NFPA)
- m. National Electrical Code (NEC)
- n. National Electrical Manufacturers Association (NEMA)
- o. National Institute of Standards and Technology (NIST)
- p. National Systems Contractors Association (NSCA)
- q. Occupational Safety and Health Administration (OSHA)
- r. Product Manufacturers within this Specification
- s. State and Local Municipality Code and Ordinances
- t. Telecommunications Industries Association (TIA)
- u. Underwriters' Laboratories (UL)

E. CURRENT VERSIONS

- 1. All products supplied shall be of the latest revision available at the time of Contract.

F. FIRMWARE

- 1. All products supplied shall have the latest firmware revision available at the time of Contract and be updated to the latest firmware revision just prior to commissioning and closeout.
- 2. Contractor shall provide and perform critical firmware updates on supplied products throughout the project warranty period. Critical updates are defined as any firmware update to correct any issue that causes the product to not function as intended resulting in a non-functional system. Non-critical firmware updates shall be postponed until just prior to commissioning and closeout.
- 3. All firmware updates shall be performed by Contractor, without charge to Owner, throughout project warranty period.

G. SOURCE CODE AND CUSTOM PROGRAMMING

- 1. For systems utilizing control system source code and or custom program/configuration files, Contractor shall supply, and transfer ownership of, all programs/files to the Owner as part of project Close-out Documentation. These files shall include, but not be limited to: uncompiled and compiled source code, customized modules, login credential documentation, etc. Any/all files and information, required to alter, update or change programming, shall be supplied to the Owner.

1.9 DELIVERY, STORAGE AND HANDLING

A. Pack and ship in accordance with manufacturer's recommendations:

- 1. Finish, assemble, and test all components in the factory before shipment.
- 2. Rack components will be sub assembled before delivery to jobsite.
- 3. Deliver components to room designated for installation.

B. Do not accept damaged products at the site. Do not install damaged products.

C. Store products in heated indoor storage near point of installation. Retain protective packaging until installing. Ship to jobsite only after roughing-in, painting work, and other related finish work has been completed and installation areas are ready to accept units and recommended temperature and humidity levels will be maintained during the remainder of construction

1.10 PROJECT CONDITIONS

- A. Environmental Requirements: Do not install system until all mortar, wet and dust producing trades have completed their work and finished floor is in place.
- B. Confirm all installation locations prior to start of work.
- C. Where code permits, wiring may be run outside of conduit. Such wiring shall be coordinated either in a plenum space or by means of secondary enclosure that meets code requirements.
- D. Field Measurements: Obtain required field measurements and indicating performance setups, ceiling construction, wall construction, ventilation features, electrical systems, networks and potential obstacles on shop drawings.

1.11 WARRANTY

- A. Manufacturer's written warranty indicating manufacturer's intent to repair or replace components of system that fail in materials or workmanship from date of Substantial Completion for the number of years indicated below.
 - 1. Parts and labor project warranty shall be one (1) year, effective at date of project completion as determined by Owner sign-off of final pay application. Project warranty shall include all costs to troubleshoot and repair any/all reported problems reported during the project warranty period.

1.12 INSTALLATION

- A. Contractor shall install, calibrate and tune system for preset environments determined by customer.
- B. Calibrate systems for proper operation.
- C. Refer to project drawings.

1.13 DEMONSTRATION

- A. Train Owner's personnel to operate and maintain systems.
- B. Include time to train owner's representative.
- C. Turn over operation and instructions to Owner.

1.14 CLOSEOUT SUBMITTALS

- A. Submittal format
 - 1. (2) USB media for:
 - a. Owner
 - b. Technology Consultant

- B. Maintenance data.
- C. Inventory data (Excel spreadsheet).
 - 1. By Building and Room:
 - a. Each product:
 - 1) Manufacturer
 - 2) Product name
 - 3) Model number
 - 4) Serial number
 - 5) MAC address (if applicable)
 - 6) IP address (if applicable)
 - 7) Network Name (if applicable)
 - 8) Owner asset tag number (if applicable)
- D. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On USB media. This shall include non-compiled source code including any program module custom to the project. All login credentials required to open/access code and modules shall be supplied.
 - 3. Printout of software application and graphic screens.
- E. Source Code and/or equipment configuration files
- F. As-Built diagrams/drawings
- G. Provide (2) copies of all Closeout Submittals (one to Owner and one to Technology Designer)

1.15 FIRESTOPPING

- A. Comply with TIA-569-D, Annex A, "Firestopping."
- B. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

1.16 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-C and NECA/BICSI-607.
- C. 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.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

1.17 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 27 0553 "Identification for Communications Systems."
- B. 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.
- C. 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.

1.18 FIELD QUALITY CONTROL

- A. 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-568.1-D.
 - 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.
 - 4. All CAT6 cables shall be certified in accordance with specification 27 1700 TESTING, IDENTIFICATION AND ADMINISTRATION OF BALANCED TWISTED PAIR INFRASTRUCTURE.
- B. 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.
- C. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

- D. Ensure EDID compliance between source and sink devices. For systems utilizing multiple displays of disparate resolutions, an EDID documentation plan shall be created prior to installation. Switchers, distribution amplifiers, and/or other distribution hardware that are intermediary between source and sink, shall be properly configured to maintain proper EDID per industry best-practice.
- E. Ensure HDCP compliance between source and sink devices. Switchers, distribution amplifiers, and/or other distribution hardware that are intermediary between source and sink, shall be properly configured to maintain proper HDCP key "handshake" per industry best-practice.
- F. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION 27 4116

SECTION 27 5123.50 - EDUCATIONAL INTERCOM AND PROGRAM 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. Failure to consult these documents shall not relieve the Contractor of requirements therein.

1.2 SUMMARY

- A. This Section includes user-programmable, multichannel, microprocessor-switched, centrally controlled, school intercommunication and program equipment.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Display Administrative Console
 - 2. Control Cabinet with Intercom/Page/Program Amplifiers
 - 3. Switching Hubs
 - 4. Loudspeakers
- B. Shop Drawings: Signed and sealed by a qualified professional engineer.
 - 1. Equipment Details: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection.
 - 2. Station-Arrangement Details: Scaled drawings for built-in equipment.
 - 3. Wiring Diagrams: Power, signal, and control wiring. Include the following:
 - a. Identify terminals to facilitate installation, operation, and maintenance.
 - b. Single-line diagram showing interconnection of components.
 - c. Cabling diagram showing cable routing.
- C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- D. Qualification Data: For Installer.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For school intercom and program equipment to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Closeout Procedures Operation and Maintenance Data," include the following:

1. Record of final matching transformer-tap settings and signal ground-resistance measurement certified by Installer.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
 1. Maintenance Proximity: Not more than one hour normal travel time from Installer's place of business to Project site.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Comply with UL 50.

1.5 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted speaker microphones and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. All Bids shall be based on the equipment as specified herein. The model numbers are that of the CareHawk CH1000LT. The specifying authority must approve any alternate system.
- B. All Bids shall be based on the equipment as specified herein. The model numbers are that of the CareHawk CH1000LT. The specifying authority must approve any alternate system.
- C. Contractors that wish to submit alternate equipment shall provide the specifying authority with the appropriate documentation, at least 15 business days prior to bid opening. The submitted documentation must provide a feature by feature comparison identifying how the proposed equipment meets the operation and functionality of the system described in this specification. Including its ability to integrate with any other CH1000LT systems installed in the school district. Contractor shall provide adequate and complete submittal information, prior to bid date, which shall include but not limited to specification sheets, working drawings, shop drawings, and a demonstration of the system. Alternate supplier-contractor must also provide a list to include six installations identical to the system proposed.

2.2 FUNCTIONAL DESCRIPTION OF MICROPROCESSOR-SWITCHED SYSTEM

A. VOICE COMMUNICATIONS

1. Furnish and install a microprocessor-controlled integrated security and voice communications system with all conduit, wire, outlets, and equipment as shown on the drawings and as herein specified to provide a complete sound, program distribution, and voice intercommunications system in the building.
2. Furnish and install the required number of Administrative Phones with all conduit, wire, outlets, and equipment as shown on the drawings.
3. All field wiring shall be standard CAT-6 type terminated with RJ45 connectors and must adhere to the structured cabling manufacturer and models specified on the drawings.
4. The system shall integrate with the owner's VoIP telephone system. The Carehawk shall provide an analog telephone interface module compatible with an FXO output of an owner-provided VoIP Gateway.

B. MASTER CLOCK

1. The Windows® based *CareHawk Calendar* PC application shall be used for all scheduling of events and schedules. Scheduling software shall be a separate application from that of what is required to configure the system. It shall not be possible to corrupt the programming of the system through the misuse of the scheduling tool. The systems shall contain separate configuration files from the scheduling files in flash memory. The software shall support remote (off-site) scheduling through the internet.
2. The system shall contain an integral master clock.
3. Each classroom port shall be programmed with a 3, 4, or 5-digit numeric dial number and caller ID information. Each classroom shall be equipped with up to eight call-in switches per port. Two user-programmable priority levels are available to each room call-in button and up to 32 call-in destination groups.
4. To place a normal call, momentarily press the call button. To upgrade to an emergency call, press the call button twice within two seconds.
5. Normal calls shall be automatically upgraded (at any time) to an emergency call by pressing the call button for twice within two seconds.

C. FIBER OPTICAL CABLE

1. The system shall allow for the network of multiple systems over fiber optic cable. Fiber connections can be dedicated or shared with the local facility LAN.

D. SYSTEM COMPONENTS

1. Provide all paging system components shown on project drawings as well as any additional components required to form a fully functioning system.

2.3 EQUIPMENT AND MATERIALS

- A. Coordinate features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
- B. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
- C. Equipment: Modular type using solid-state components, fully rated for continuous duty, unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.
- D. Waterproof Equipment: Listed and labeled for duty outdoors or in damp locations.

2.4 ADMINISTRATIVE PHONE (AP1)

- A. The AP1 shall be desk-mounted or wall-mounted, and contains a matching telephone handset with retractable coiled cord and plastic button switches, with clearly designated touch points. The housing shall be constructed of high impact, flame retardant, plastic. Wall terminations shall be a RJ-45 modular telephone type jack.
- B. Features shall include:
 - a. Large, easy-to-read, adjustable, 8 line by 20-character alphanumeric backlit LCD display
 - b. Menu-driven display for ease-of-operation
 - c. Handset and speakerphone
 - d. Numeric 3, 4, or 5 digit dialing
 - e. ADSI Capable
 - f. Distinctive electronic ring signals
 - g. Twelve-button key pad
 - h. Soft function keys
 - i. RJ12 type modular connector
 - j. Call queuing
 - k. Telephone-style handset
 - l. Hold button
 - m. Off hook LED
 - n. Message waiting LED
 - o. 200 Speed dials

2.5 SPEAKER MICROPHONES

- A. Provide and install speakers as indicated on project drawings.

2.6 CONDUCTORS AND CABLES

- A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG.
- B. Insulation: Thermoplastic, not less than 1/32 inch thick.

- C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.

- 1. Minimum Shielding Coverage on Conductors: 60 percent.

- D. Plenum Cable: Listed and labeled for plenum use.

2.7 UNINTERRUPTABLE POWER SUPPLY

- A. Provide a UPS with wall mounted shelf. Unit shall be APC SMART-UPS 1000VA LCD 120V.

- 2.8 Provide auxiliary power amplifiers for loudspeaker circuits as indicated on system riser diagrams. Amplifiers shall be Carehawk DAF series with AT1 Input attenuator module between SS16/32 port and amplifier input. Amplifiers will allow for additional headroom as indicated on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wiring Method: Install wiring in raceways except within consoles, desks, and counters. Conceal cables and raceways except in unfinished spaces.
- B. Wiring Method: Install wiring in raceways except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Use plenum cable in environmental air spaces, including plenum ceilings. Conceal cables and raceways except in unfinished spaces.
- C. Install exposed cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables with hook and loop straps. Secure cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, or fittings.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess. Use lacing bars in cabinets.
- E. Control-Circuit Wiring: Install number and size of conductors as recommended by system manufacturer for control functions indicated.
- F. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches for speaker microphones and adjacent parallel power and telephone wiring. Separate other school intercom and program equipment conductors as recommended by equipment manufacturer.
- G. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- H. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

- I. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
- J. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
- K. Connect wiring according to Division 26 Section "Low Voltage Electrical Power Conductors and Cables."

3.2 GROUNDING

- A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
- C. Install grounding electrodes as specified in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.3 SYSTEM PROGRAMMING

- A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing]. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Schedule tests with at least seven days' advance notice of test performance.
 - 2. After installing school intercom and program equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 3. Operational Test: Test originating station-to-station, all-call, and page messages at each intercom station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
 - 4. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
 - 5. Test and record impedance of individual station circuits.
- C. Retesting: Correct deficiencies and retest. Prepare a written record of tests.
- D. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.

E. Prepare written test reports.

1. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service and initial system programming.
- B. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
- C. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

- A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain school intercom and program equipment. Refer to Division 01 Section "Closeout Procedures Demonstration and Training." Minimum of four trips of two hours each trip.
 1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining equipment.

END OF SECTION 27 5123.50

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27 5313.10 – CLOCK SYSTEMS

1 GENERAL

1.01 SUMMARY OF WORK

- A. This Section specifies materials and accessories for the clock system.
- B. Section Includes:
 - 1. Analog and digital wireless-sync clocks.

1.02 RELATED REQUIREMENTS

- A. Section 27 0500 - Common Work Results for Communications.
- B. Section 27 1513 - Communications Horizontal Cabling.

1.03 REFERENCE STANDARDS

- A. Federal Communications Division (FCC)
 - 1. Part 15 - Code of Federal Regulations.
- B. Institute of Electrical and Electronics Engineers (IEEE)
 - 1. IEEE 802.3af-[1998], Standard for Information Technology - Telecommunications and Information Exchange Between Systems.
- C. National Fire Protection Association (NFPA).
 - 1. NFPA 70E-[2012], Standard for Electrical safety in the Workplace.
- D. Underwriter's Laboratories (UL)

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate work of this Section with communications and electronics work and with work of other trades for proper time and sequence to avoid construction delays.

1.05 ACTION AND INFORMATIONAL SUBMITTALS

- A. Make submittals in accordance with Project Manual section(s) pertaining to submittals.
- B. Product Data: Submit product data including manufacturer's literature for clock system materials and accessories, indicating compliance with specified requirements and material characteristics.
- C. Subcontractor Experience: Submit verification of communication and electronics subcontractor's experience.

D. Manufacturer's Authorization: Submit verification that of communication and electronics subcontractor's authorization from clock system manufacturer to perform Work of this section.

1.06 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Supply maintenance data for clock system.
- B. Record Documentation: In accordance with Project Manual section pertaining to Closeout Submittals.
1. List materials used in clock system work.
 2. Warranty: Submit warranty documents specified.

1.07 QUALITY ASSURANCE

- A. Communications and Electronics Subcontractor Quality Assurance:
1. Work experience of [3] years minimum with work similar to work of this Section.
 2. Manufacturer's authorization to perform work of this section.
- B. Supplier's Accreditation: Use only suppliers accredited by clock system manufacturer.
- C. Supplier's Maintenance Requirements:
1. Ensure local supplier has adequate facility for storage of spare parts for clock system.

1.08 DELIVERY STORAGE AND HANDLING

- A. Delivery and Acceptance Requirements:
1. Deliver materials and accessories in clock system manufacture's original packaging with identification labels intact and to suit project.
 2. Ensure clock system materials are not exposed to moisture during delivery.
 3. Replace damaged clock system materials.
- B. Storage and Handling Requirements: Store materials off ground in dry location and protected from exposure to fumes and harmful weather conditions and at temperature conditions recommended by manufacturer.
1. Store in original packaging until installed.
- C. Packaging Waste Management:
1. Remove waste packaging materials from site and dispose of packaging materials at appropriate recycling facilities.
 2. Collect and separate for disposal, paper and plastic material in appropriate on-site storage containers for recycling [in accordance with Waste Management Plan].

1.09 WARRANTY

- A. Project Warranty: Refer to Contract Conditions for project warranty provisions. All components and workmanship must be warrantied for no less than one year.
- B. Manufacturer's warranty: Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official. Manufacturer's warranty is in addition to and not

intended to limit other rights Owner may have under Contract Conditions.

2 PRODUCTS

2.02 SYSTEM REQUIREMENTS

- A. Ensure clock system components are designed to operate as part of complete system and include “fail-proof” design to ensure power interruption does not cause system failure.
- B. Ensure system can work in conjunction with data wiring.
- C. Ensure system synchronizes all clocks and devices to each other.
- E. Ensure system works with monitoring software for system controls from one location and including options as follow:
 - 1. Mark clocks as priority for quick viewing;
 - 2. Uploading and downloading configuration capabilities;
 - 3. Sending numeric messages to digital clocks;
 - 4. Sending countdown functions to digital clocks;
 - 5. Sending alphanumeric messages to digital clocks;
- F. Ensure system monitor is run on PC on same network as clock system.
 - 1. Server installation is not required.
- G. Ensure system is capable of operating without physical servers and software.

2.03 COMPONENTS

- A. Provide and install all clock components as shown on project drawings.

3 EXECUTION

3.01 INSTALLERS

- A. Use only installers with [3] years minimum experience with work similar to work of this Section.
- B. Ensure all clock system components are installed by single communications and electronics subcontractor.

3.02 EXAMINATION

- A. Verification of Conditions: Verify that conditions of substrate previously installed under other Sections or Contracts are acceptable for clock system installation in accordance with manufacturer’s written recommendations.
 - 1. Proceed with installation only after unacceptable conditions have been remedied and after receipt of written approval to proceed from Consultant.

- B. Start of clock system installation indicates installer's acceptance of substrate installation conditions.

3.03 INSTALLATION

- A. Install clock system in accordance with manufacturer's written recommendations and in accordance with NFPA 70E.
- B. Integrate clock system with Owner's electrical and communications network.
- C. Coordinate required IP and NTP server address requirements with Owner IT department.
- D. Install clocks only after painting and other finish work is completed in each room.
- E. Install clocks and other devices square and plumb.

3.04 FIELD QUALITY CONTROL

- A. Field Inspection: Coordinate field inspection in accordance with Project Manual sections referencing quality control requirements.

3.05 SYSTEM STARTUP

- A. At completion of installation and before final acceptance, turn on equipment and ensure equipment is operating properly, and clock system devices and components are functioning.
- B. Evaluate and test each device in clock system on room-by-room basis using factory-trained technicians.
 - 1. Fix or replace devices which fail test or are functioning incorrectly.
 - 2. Submit evaluation and report showing results of room-by-room tests and overall system compliance within 3 days of testing being carried out.

3.06 CLEANING

- A. Progress Cleaning: Perform cleanup as work progresses
 - 1. Leave work area clean at end of each day.
- B. Final Cleaning: Upon completion, remove surplus materials, rubbish, tools, and equipment.

3.07 DEMONSTRATION AND TRAINING

- A. Arrange system demonstration and training session for Owner's operation and maintenance personnel.
 - 1. Allow Owner and Consultant [7] days minimum advance notice before training session.
- B. Break down system demonstration and training session into logical segments for Owner's

operations and maintenance personnel.

C. Train Owner's maintenance personnel in procedures and schedules involved in operating, troubleshooting, servicing, and preventative maintenance of clock system.

3.08 PROTECTION

A. Protect installed products and accessories from damage during construction.

B. Repair damage to adjacent materials caused by clock system installation.

END OF SECTION 27 5313.10

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SECTION 28 1400 – ACCESS CONTROL SYSTEM HARDWARE

PART 1 - GENERAL

1.1 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. Executive Summary: Includes the procurement and installation of an access control platform, the credentials (fobs, cards, etc.), and the setup and programming of the user's database.
- B. Section Includes:
 - 1. Access control panel hardware and power supply requirements
 - 2. One or more security access networked workstations.
 - 3. Security access operating system and application software.
 - 4. Security access controllers connected to high-speed electronic-data transmission network.
- C. Related Requirements:
 - 1. Section 28 1500 "Access Control System Hardware Devices" for access control system hardware, such as keypads, card readers, and biometric identity devices.

1.3 DEFINITIONS

- A. Credential: Data assigned to an entity and used to identify that entity.
- B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- C. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
- D. Location: A Location on the network having a workstation-to-controller communications link, with additional controllers at the Location connected to the workstation-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
- E. Workstation: Personal computer. Applies to the central station, workstations, and file servers.
- F. RAS: Remote access services.
- G. RF: Radio frequency.
- H. ROM: Read-only memory. ROM data are maintained through losses of power.

- I. TCP/IP: Transport control protocol/Internet protocol.
- J. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- K. WMP: Windows media player.
- L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- M. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
 - 1. Any product data sheets with multiple models shall include indication of specific models to be provided per this document.
- B. Panel layout information. At the time of submittal, the following information shall be provided on a spreadsheet:
 - 1. Number of network control panels to be provided and initial estimation of access controlled doors/openings per panel;
 - 2. Number of input and output modules and initial estimation of inputs and outputs to be configured
- C. Initial programming acknowledgement per door/opening, based on the following:
 - 1. Access control door schedule on plans.
 - 2. Doors to be included in lockdown activation
 - 3. Sequence of operations for unlocked hours, locked hours, and lockdown conditions per door as specified in plans.
- D. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.
- E. Product Schedules.

- F. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - 1. Workstation operating system documentation.
 - 2. Workstation installation and operating documentation, manuals, and software for the workstation and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each workstation.
 - 3. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on USB media of the hard-copy submittal.
 - 4. System installation and setup guides with data forms to plan and record options and setup decisions.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Central Station, Workstations, and Controllers:
 - 1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F, and not more than 80 percent relative humidity, noncondensing.
 - 2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.

3. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" Article.
4. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
 2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in air-conditioned indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
 3. Indoor, Uncontrolled Environment: NEMA 250, Type 4 enclosures. System components installed in non-air-conditioned indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
 4. Outdoor Environment: NEMA 250, NEMA 250, Type 3R enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.
 5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
 6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

PART 2 - PRODUCTS

2.1 ACCESS CONTROL SOFTWARE

- A. Manufacturers: Subject to compliance with requirements, **provide products by or based around the following:**
1. Products
 - a. Head end software capable of the following:
 - 1) Database capable, at minimum, of:
 - a) 10,000 cardholders
 - b) 10 Unique User roles
 - c) 5 simultaneous users
 - d) 1 million transaction/records/events
 - e) Networked communication with head end panels (below)
 - 2) Integration with visitor management systems, Video Management Systems (VMS), and intrusion/burglary systems.

- 3) Local and remote administration
- 4) 24/7 remote monitoring by both onsite and offsite personnel
- 5) Graphic User Interface (GUI) capable of displaying the following:
 - a) Building Layout
 - b) Devices and their location in the building
 - c) Active alarms
 - d) Acknowledged events
 - e) Recent activity, minimum 25 events
 - f) Ability to select a door or device and instantly control (temp lock/unlock, scheduled lock/unlock, recent activity/events, etc.)
- b. System Controller and Reader Interfaces
 - 1) Capable of:
 - a) Networked communication via LAN and WAN
 - b) Communicating and sharing a singular database
 - c) Local storage of database and access levels
 - d) Local (offline) operation in case of network loss
 - e) Expandability to 64 modules per networked controller
 - f) Alarm at minimum for tamper, comm loss, and system faults sent to Owner-defined personnel via SMS, email, or other communication method
 - g) Preferred Mercury hardware
 - h) OSDP and Wiegand comm protocol options preferred
 - 2) Programming levels, at minimum:
 - a) Door by door scheduling
 - b) Grouped door scheduling
 - 3) Controllers capable of expanding up to 64 doors on a single networked controller
 - 4) Reader interfaces capable of operating in a "local" or "offline" mode in case of network failure.
- c. Enclosures
 - 1) Preferred access control enclosures centralize controller, reader interface modules, and power supplies in network closet or other determined area, *not* above each door.
- d. Power Supplies and enclosures – provide quantities based on manufacturer's recommendations and size requirements. Power supplies to provide power to both access control and door locking hardware.

2.2 DESCRIPTION

- A. Security Access System: Workstation-based central station and field-installed controllers, connected by a high-speed electronic-data transmission network.
- B. System Software: Based on 64-bit, central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:
 1. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
 2. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of the operating system.
 3. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
 4. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.

5. Password-protected operator login and access.
 6. Open-database-connectivity compliant.
- C. Network connecting the central station and workstations shall be a LAN using TCP/IP with a capacity of connecting up to 20 workstations. System shall be portable across multiple communication platforms without changing system software.
- D. Network(s) connecting workstations and controllers shall consist of one or more of the following:
1. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet, star topology network based on TCP/IP.
 2. Local area, IEEE 802.11 compatible wireless mesh network, based on TCP/IP.

2.3 OPERATION

- A. Security access system shall use a single database for access-control and credential-creation functions.
- B. Distributed Processing: A fully distributed processing system.
1. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
 2. Intermediate controllers for access control are prohibited.
 3. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.
- C. Number of Locations:
1. Support at least 32 separate Locations using a single workstation with combinations of direct-connect, or TCP/IP LAN connections to each Location.
 2. Each Location shall have its own database and history in the central station.
 3. Locations may be combined to share a common database.
- D. System Network Requirements:
1. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
 2. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
 3. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
 4. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.
- E. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.
- F. Field equipment shall include controllers, sensors, and controls.

1. Controllers shall serve as an interface between the central station and sensors and controls.
 2. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.
 3. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
 4. Controllers are classified as alarm-annunciation or entry-control type.
- G. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.
- H. Error Detection:
1. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the central station.
 2. Interactive or product error-detection codes alone will not be acceptable.
 3. A message shall be in error if one bit is received incorrectly.
 4. Retransmit messages with detected errors.
 5. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
 6. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
 7. Monitor the frequency of data transmission failure for display and logging.
- I. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
- J. Door Hardware Interface:
1. Comply with requirements in Section 08 7100 "Door Hardware" and Section 08 7111 "Door Hardware (Descriptive Specification)" for door hardware required to be monitored or controlled by the security access system.
 2. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

2.4 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 NFPA 70, "National Electrical Code."
- C. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07.

2.5 APPLICATION SOFTWARE

- A. System Software: Based on 32-bit, Microsoft Windows central-station and workstation operating system and application software.

1. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
 2. Graphical user interface shall show pull-down menus and a menu-tree format.
 3. Capability for future additions within the indicated system size limits.
 4. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
 5. Password-protected operator login and access.
- B. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.
- C. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors, operate displays, report alarms, generate reports, and help train system operators.
1. Reside at the central station, workstations, and controllers as required to perform specified functions.
 2. Operate and manage peripheral devices.
 3. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
 4. Import custom icons into graphics to represent alarms and I/O devices.
 5. Globally link I/O so that any I/O can link to any other I/O within the same Location without requiring interaction with the host workstation. This operation shall be at the controller.
 6. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host workstation. This operation shall be at the controller.
 7. Messages from workstation to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
 8. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other workstation-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
 9. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control workstation and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
 10. Operator audit trail for recording and reporting all changes made to database and system software.
 11. Support network protocol and topology, TCP/IP, Novel Netware, Digital Pathworks, Banyan Vines, LAN/WAN, and RAS.
- D. Workstation Software:
1. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
 2. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.
- E. Controller Software:
1. Controllers shall operate as autonomous, intelligent processing units.
 - a. Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
 - b. Controllers shall be part of a fully distributed processing-control network.

- c. The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.
2. The following functions shall be fully implemented and operational within each controller:
 - a. Monitoring inputs.
 - b. Controlling outputs.
 - c. Automatically reporting alarms to the central station.
 - d. Reporting of sensor and output status to the central station on request.
 - e. Maintaining real time, automatically updated by the central station at least once a day.
 - f. Communicating with the central station.
 - g. Executing controller resident programs.
 - h. Diagnosing.
 - i. Downloading and uploading data to and from the central station.
3. Controller Operations at a Location:
 - a. Up to 64 controllers connected to TIA 485-A communications loop. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti-passback shall remain fully functional within the same Location even when the central station or workstations are off-line.
 - b. In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
 - c. Buffered events shall be handled in a first-in-first-out mode of operation.
4. Individual Controller Operation:
 - a. Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.
 - b. Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.
 - c. Controllers shall provide a response to card readers or keypad entries in less than 0.25 seconds, regardless of system size.
 - d. Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.
 - e. Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.
 - f. On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.
 - g. After power is restored, following a power failure, startup software shall initiate self-test diagnostic routines, after which controllers shall resume normal operation.
 - h. After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until repaired. If database and

application programs are resident, controllers shall immediately resume operation. If not, software shall be restored automatically from the central station.

5. Communications Monitoring:
 - a. System shall monitor and report status of TIA 485-A communications loop of each Location.
 - b. Communication status window shall display which controllers are currently communicating, a total count of missed polls since midnight, and which controller last missed a poll.
 - c. Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM for each controller.
6. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.

F. workstation-to-Controller Communications:

1. Central-station or workstation communications shall use the following:
 - a. Direct connection using serial ports of the workstation.
 - b. TCP/IP LAN interface cards.
 - c. Dial-up or cable modems for connections to Locations.
2. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.
3. Use multiport communications board if more than two serial ports are needed.
 - a. Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
 - b. Connect the first board to an internal PCI bus adapter card.
4. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.
5. TCP/IP network interface card (NIC) shall have an option to set the poll-frequency and message-response time-out settings.
6. Workstation-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered, and retransmitted if not acknowledged.

G. Direct Serial or TCP/IP workstation-to-Controller Communications:

1. Communication software on the workstation shall supervise the workstation-to-controller communications link.
2. Loss of communications to any controller shall result in an alarm at all workstations running the communication software.
3. When communications are restored, all buffered events shall automatically upload to the workstation, and any database changes shall be automatically sent to the controller.

H. Broadband Workstation-to-Controller Communications:

1. Communication software on the workstation shall supervise the workstation-to-controller communications link during dial-up modem connect times.
 2. Communication software shall be programmable to routinely poll each of the remote dial-up or cable modem Locations, collecting event logs and verifying phone lines at operator-selectable time intervals for each Location.
 3. System shall be programmable for dialing and connecting to all dial-up or cable modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
 4. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the workstation.
 5. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host workstation will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host workstation.
 6. The controller connected to a dial-up or cable modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the controller shall automatically initiate a call to the central station and upload all transactions.
 7. Alarms shall be reported immediately.
 8. Dial-up or cable modems shall be provided by manufacturer of the system. Modems used at the controller shall be powered by the controller. Power to the modem shall include battery backup if the controller is so equipped.
- I. Controller-to-Controller Communications:
1. TIA 485-A, four-wire, point-to-point, regenerative (repeater) communications network methodology.
 2. TIA 485-A communications signal shall be regenerated at each controller.
- J. Database Downloads:
1. All data transmissions from workstations to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
 2. If a controller is reset for any reason, it shall automatically request and receive a database download from the workstation. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.
- K. Operator Interface:
1. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
 2. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
 3. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
 4. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
 5. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
 6. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:

- a. Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
 - b. Maps to provide real-time display animation and allow for control of points assigned to them.
 - c. System to allow inputs, outputs, and override groups to be placed on different maps.
 - d. Software to allow changing the order or priority in which maps will be displayed.
 7. Override Groups Containing I/Os:
 - a. System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
 - b. Icon shall change automatically to show the live summary status of points in that group.
 - c. Override group icon shall provide a method to manually control or set to time-zone points in the group.
 - d. Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.
 8. Schedule Overrides of I/Os and Override Groups:
 - a. To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
 - b. Each schedule shall be composed of a minimum of two dates with separate times for each date.
 - c. The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
 - d. The second time and date shall be assigned the state that the point shall return to when the time and date become current.
 9. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.
- L. Operator Access Control:
1. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
 2. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
 3. A minimum of 3 unique user accounts shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
 4. The password shall not be displayed or printed.
 5. Each password shall be definable and assignable for the following:
 - a. Selected commands to be usable.
 - b. Access to system software.
 - c. Access to application software.
 - d. Individual zones that are to be accessed.
 - e. Access to database.
- M. Operator Commands:

1. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
2. Command inputs shall be acknowledged and processing shall start in not less than one second(s).
3. Tasks that are executed by operator's commands shall include the following:
 - a. Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
 - b. Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
 - c. Place Zone in Secure: Used to remotely activate intrusion-alarm circuits emanating from a specific zone.
 - d. System Test: Allows the operator to initiate a system-wide operational test.
 - e. Zone Test: Allows the operator to initiate an operational test for a specific zone.
 - f. Print reports.
 - g. Change Operator: Used for changing operators.
 - h. Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
 - i. Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
 - j. Run system tests.
 - k. Generate and format reports.
 - l. Request help with the system operation.
 - 1) Include in main menus.
 - 2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
 - 3) Provide navigation to specific topic from within the first help window.
 - 4) Help shall be accessible outside the application program.
 - m. Entry-Control Commands:
 - 1) Lock (secure) or unlock (open) each controlled entry and exit up to 10 times a day through time-zone programming.
 - 2) Arm or disarm each monitored input up to 10 times a day through time-zone programming.
 - 3) Enable or disable readers or keypads up to 5 times a day through time-zone programming.
 - 4) Enable or disable cards or codes up to 5 times a day per entry point through access-level programming.
4. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:
 - a. Command entered is incorrect or incomplete.
 - b. Operator is restricted from using that command.
 - c. Command addresses a point that is disabled or out of service.
 - d. Command addresses a point that does not exist.
 - e. Command is outside the system's capacity.

N. Alarms:

1. System Setup:

- a. Assign manual and automatic responses to incoming-point status change or alarms.
 - b. Automatically respond to input with a link to other inputs, outputs, or operator-response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
 - c. Sixty-character message field for each alarm.
 - d. Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to access point.
 - e. Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
 - f. Allow 25 secondary messages with a field of four lines of 60 characters each.
 - g. Store the most recent 1000 alarms for recall by the operator using the report generator.
 2. Software Tamper:
 - a. Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
 - b. Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.
 - c. Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
 - d. Allow only acknowledgment of software tamper alarms.
 3. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
 4. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
 5. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
 6. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a TIA 232-F ASCII interface.
 7. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
 8. Camera Control: Provides operator ability to select and control cameras from graphic maps.
- O. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.
1. Displayed alarm data shall include type and location of alarm. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
 2. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
 3. Alarms initiate a status of "pending" and require the following two handling steps by operators:
 - a. First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."

- b. Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
 - 4. Each workstation shall display the total pending alarms and total unresolved alarms.
 - 5. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
 - 6. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
 - 7. Alarms shall be displayed and managed from a minimum of four different windows.
 - a. Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
 - b. History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
 - c. Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
 - d. Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
 - 8. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
 - 9. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
 - 10. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
 - 11. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
 - 12. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.
 - 13. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.
- P. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.
- 1. Color Code:
 - a. FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
 - b. STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
 - c. YELLOW: Advises operator that a zone is in access.
 - d. GREEN: Indicates that a zone is secure and that power is on.
 - 2. Graphics:
 - a. Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
 - b. Allow I/O to be placed on graphic maps by the drag-and-drop method.
 - c. Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
 - d. Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.

- e. Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
 - f. Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
 - g. Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.
- Q. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.
- 1. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.
- R. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.
- 1. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
 - 2. Printing on Request: An operator may request a printout of any report.
 - 3. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm (such as door alarm, intrusion alarm, tamper alarm, etc.), the type of sensor, the location, the time, and the action taken.
 - 4. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
 - 5. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
 - 6. Automatic History Reports: Named, saved, and scheduled for automatic generation.
 - 7. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
 - 8. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
 - 9. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
 - 10. Who Is "In" (Muster) Report:
 - a. Emergency Muster Report: One-click operation on toolbar launches report.
 - b. Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
 - 11. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
 - 12. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.
 - a. Initially store history on the hard disk of the host workstation.
 - b. Permit viewing of the history on workstations or print history to any system printer.

- c. The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
 - d. Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.
 - e. Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
 - f. Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.
13. Reports shall have the following four options:
 - a. View on screen.
 - b. Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
 - c. "Save to File" with full path statement.
 - d. System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.
14. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:
 - a. Active, inactive, or future activate or deactivate.
 - b. Code number, name, or imprinted card number.
 - c. Group, Location access levels.
 - d. Start and stop code range.
 - e. Codes that have not been used since a selectable number of days.
 - f. In, out, or either status.
 - g. Codes with trace designation.
15. The reports of system database shall allow options so that every data field may be printed.
16. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.

S. Anti-Passback:

1. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
2. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
3. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.
4. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
5. Provide four separate zones per Location that can operate without requiring interaction with the host workstation (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.
6. The anti-passback schemes shall be definable for each individual door.
7. The Master Access Level shall override anti-passback.

8. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.
- T. Visitor Assignment:
1. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.
 2. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.
 3. Allow a visitor designation to be assigned to a credential holder.
 4. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
 5. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
 6. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
 7. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.
- U. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.
- V. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.
1. The enrollment station shall not have alarm response or acknowledgment functions.
 2. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
 3. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
 4. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity-verification subsystems, . Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
 5. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:
 - a. MASK: Determines a specific format with which data must comply.
 - b. REQUIRED: Operator is required to enter data into field before saving.
 - c. UNIQUE: Data entered must be unique.
 - d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
 - e. NAME ID: Data entered will be considered a unique ID for the cardholder.
 6. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.

7. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.
8. Batch card printing.
9. Default card data can be programmed to speed data entry for sites where most card data are similar.
10. Enhanced ASCII File Import Utility: Allows the importing of cardholder data and images.
11. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

2.6 SYSTEM DATABASE

- A. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.
- B. Database Operations:
 1. System data management shall be in a hierarchical menu-tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
 2. Navigational Aids:
 - a. Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
 - b. Point and click feature to facilitate data manipulation.
 - c. Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
 - d. Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.
 3. Data entry shall be automatically checked for duplicate and illegal data and shall be verified for valid format.
 4. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo field is used for noting the purpose for which the item was entered, reasons for changes that were made, and the like.
- C. File Management:
 1. File management shall include database backup and restoration system, allowing selection of storage media, including 3.5-inch floppy disk, Zip and Jaz drives, and designated network resources.
 2. Operations shall be both manual and automatic modes. The number of automatic sequential backups before the oldest backup will be overwritten; FIFO mode shall be operator selectable.
 3. Backup program shall provide manual operation from any workstation on the LAN and shall operate while system remains operational.
- D. Operator Passwords:
 1. Support up to 32,000 individual system operators, each with a unique password.
 2. One to eight alphanumeric characters.
 3. Allow passwords to be case sensitive.
 4. Passwords shall not be displayed when entered.

5. Passwords shall have unique and customizable password profile, and allow several operators to share a password profile. Include the following features in the password profile:
 - a. Predetermine the highest-level password profile for access to all functions and areas of program.
 - b. Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
 - c. Restrict doors to which an operator can assign access.
 6. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
 7. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.
- E. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).
1. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
 2. Use data-entry windows to view, edit, and issue access levels. Access-authorization entry-management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
 3. Allow assignment of multiple cards/codes to a cardholder.
 4. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
 5. Each door may be assigned four time zones.
 6. Access codes may be up to 11 digits in length.
 7. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
 8. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
 9. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visible annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
 10. Allow each cardholder to be given either an unlimited number of uses or a number from one to 9999 that regulates the number of times the card can be used before it is automatically deactivated.
 11. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.
- F. Security Access Integration:
1. Photo ID badging and photo verification shall use the same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.
 2. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
 3. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.
- G. Operator Comments:
1. With the press of one appropriate button on the toolbar, the user shall be permitted to enter operator comments into the history at any time.

2. Automatic prompting of operator comment shall occur before the resolution of each alarm.
3. Operator comments shall be recorded by time, date, and operator number.
4. Comments shall be sorted and viewed through reports and history.
5. The operator may enter comments in two ways; either or both may be used:
 - a. Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
 - b. Predefined and stored in database for retrieval on request.
6. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.

H. Group:

1. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.
2. System software shall have the capacity to assign one of 32,000 group names to an access authorization.
3. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
4. Allow sorting of history reports and code list printouts by group name.

I. Time Zones:

1. Each zone consists of a start and stop time for seven days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
2. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
3. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
4. System shall have the capacity for 2048 time zones for each Location.

J. Holidays:

1. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YYYY and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time-zone schedule for that 24-hour period.
2. System shall have the capacity for 32,000 holidays.
3. Three separate holiday schedules may be applied to a time zone.
4. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in the system and will not be purged.
5. Holidays not designated to occur each year shall be automatically purged from the database after the date expires.

K. Access Levels:

1. System shall allow for the creation of up to 32,000 access levels.

2. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
3. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
4. System shall be able to create multiple door and time-zone combinations under the same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same controller.

L. User-Defined Fields:

1. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
2. System shall accommodate a title for each field; field length shall be 20 characters.
3. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
4. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
5. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.
6. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YYYY date format. The credential of the holder will be deactivated on that date.
7. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include a search for a character string.
8. System shall have the ability to print cardholders based on and organized by the user-defined fields.

2.7 SURGE AND TAMPER PROTECTION

- A. Surge Protection:** Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.
1. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Section 26 4313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 26 4313 "Surge Protection for Low-Voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
- B. Tamper Protection:** Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

2.8 CONTROLLERS

- A. Controllers:** Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the central station or workstation for controlling its operation.

- B. Subject to compliance with requirements in this article, manufacturers may use multipurpose controllers.
- C. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.
- D. Alarm Annunciation Controller:
 - 1. The controller shall automatically restore communication within 10 seconds after an interruption with the field device network.
 - a. Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
 - b. Alarm-Line Supervision:
 - 1) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal, and for conditions as described in UL 1076 for line security equipment by monitoring for abnormal open, grounded, or shorted conditions using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of 5 percent or more for longer than 500 ms.
 - 2) Transmit alarm-line-supervision alarm to the central station during the next interrogation cycle after the abnormal current condition.
 - c. Outputs: Managed by central-station software.
 - 2. Auxiliary Equipment Power: A GFI service outlet inside the controller enclosure.
- E. Entry-Control Controller:
 - 1. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, door strikes, magnetic latches, gate and door operators, and exit push buttons.
 - a. Operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the controller and the field-device network.
 - b. Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:
 - 1) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
 - 2) Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control.
 - c. Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
 - 2. Inputs:
 - a. Data from entry-control devices; use this input to change modes between access and secure.
 - b. Database downloads and updates from the central station that include enrollment and privilege information.
 - 3. Outputs:
 - a. Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
 - b. Grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.

- c. Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the central station.
 - d. Door Prop Alarm: If a portal is held open for longer than 60 seconds, alarm sounds.
- 4. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
- 5. Data Line Problems: For periods of loss of communication with the central station, or when data transmission is degraded and generating continuous checksum errors, the controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.
 - a. Store up to 1000 transactions during periods of communication loss between the controller and access-control devices for subsequent upload to the central station on restoration of communication.
- 6. Controller Power: NFPA 70, Class II power-supply transformer, with 12- or 24-V ac secondary, backup battery and charger.
 - a. Backup Battery: Premium, valve-regulated, recombinant-sealed, lead-calcium battery; spill proof; with a full one-year warranty and a pro rata 19-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - b. Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
 - c. Backup Power-Supply Capacity: 90 minutes of battery supply. Submit battery and charger calculations.
 - d. Power Monitoring: Provide manual, dynamic battery-load test, initiated and monitored at the control center; with automatic disconnection of the controller when battery voltage drops below controller limits. Report by using local controller-mounted digital displays and by communicating status to central station. Indicate normal power on and battery charger on trickle charge. Indicate and report the following:
 - 1) Trouble Alarm: Normal power-off load assumed by battery.
 - 2) Trouble Alarm: Low battery.
 - 3) Alarm: Power off.

2.9 DOOR AND GATE HARDWARE INTERFACE

- A. Exit Device with Alarm: Operation of the exit device shall generate an alarm. Exit device and alarm contacts are specified in Section 08 7100 "Door Hardware."
- B. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Section 08 7100 "Door Hardware."
- C. Electric Door Strikes: Use end-of-line resistors to provide power-line supervision. Signal switches shall transmit data to controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and they shall report a forced entry. Power and signal shall be from the controller. Electric strikes are specified in Section 08 7100 "Door Hardware."

- D. Electromagnetic Locks: End-of-line resistors shall provide power-line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the controller. Electromagnetic locks are specified in Section 08 7100 "Door Hardware."
- E. Vehicle Gate Operator: Interface electrical operation of gate with controls in this Section. Vehicle gate operators shall be connected, monitored, and controlled by the security access controllers. Vehicle gate and accessories are specified in Section 32 3113 "Chain Link Fences and Gates."

2.10 FIELD-PROCESSING SOFTWARE

A. Operating System:

- 1. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.
- 2. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
- 3. Execution of local processor application programs shall utilize the data in memory resident files.
- 4. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.
- 5. Local processor real-time clock shall be automatically synchronized with the central station at least once per day to plus or minus 10 seconds (the time synchronization shall be accomplished automatically, without operator action and without requiring system shutdown).

B. Startup Software:

- 1. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
- 2. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
- 3. Initiates operation of self-test diagnostic routines.
- 4. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
- 5. If the database and application programs are resident, the local processor shall immediately resume operation.

C. Operating Mode:

- 1. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
- 2. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.
- 3. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
- 4. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
- 5. Local processors shall accept software downloaded from the central station.
- 6. Panel shall support flash ROM technology to accomplish firmware downloads from a central location.

- D. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.
- E. Functions:
 - 1. Monitoring of inputs.
 - 2. Control of outputs.
 - 3. Reporting of alarms automatically to the central station.
 - 4. Reporting of sensor and output status to central station upon request.
 - 5. Maintenance of real time, automatically updated by the central station at least once a day.
 - 6. Communication with the central station.
 - 7. Execution of local processor resident programs.
 - 8. Diagnostics.
 - 9. Download and upload data to and from the central station.

2.11 FIELD-PROCESSING HARDWARE

- A. Alarm Annunciation Local Processor:
 - 1. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
 - 2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
 - 3. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
 - 4. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
 - 5. Local processor shall report line supervision alarms to the central station.
 - 6. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
 - 7. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
 - 8. Local processor outputs shall reflect the state of commands issued by the central station.
 - 9. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
 - 10. Local processor shall have at least four command outputs.
 - 11. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
- B. Processor Power Supply:
 - 1. Local processor and sensors shall be powered from an uninterruptible power source.
 - 2. Uninterruptible power source shall provide eight hours of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
 - 3. If the facility is without an emergency generator, the uninterruptible power source shall provide 24 hours of battery backup power.
 - 4. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.

5. Batteries shall be sealed, non-outgassing type.
 6. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
 7. Loss of primary power shall be reported to the central station as an alarm.
- C. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.
- D. Entry-Control Local Processor:
1. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
 2. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
 3. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, door strikes, magnetic latches, gate and door operators, and exit push buttons.
 4. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
 5. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
 6. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.
 7. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
 8. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
 9. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
 10. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
 11. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
 12. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
 13. Local processor shall report line supervision alarms to the central station.
 14. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.
 15. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
 16. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
 17. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
 18. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain a date-time- and location-stamped record of each transaction.

19. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
20. Local processor outputs shall reflect the state of commands issued by the central station.
21. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
22. Local processor shall have at least four addressable outputs.
23. The entry-control local processor shall also provide control outputs to portal-control devices.
24. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
25. The system manufacturer shall provide strategies for downloading database information for panel configurations and cardholder data to minimize the required download time when using IP connectivity.

2.12 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to workstations, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
 1. Record setup data for control station and workstations.
 2. For each Location, record setup of controller features and access requirements.
 3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
 4. Assign action message names and compose messages.
 5. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
 6. Prepare and install alarm graphic maps.

7. Develop user-defined fields.
8. Develop screen layout formats.
9. Discuss badge layout options; design badges.
10. Complete system diagnostics and operation verification.
11. Prepare a specific plan for system testing, startup, and demonstration.
12. Develop acceptance test concept and, on approval, develop specifics of the test.
13. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.

- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 27 0553 "Identification for Communications Systems" and with TIA 606-B.
- B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. Label each panel with the readers and inputs/outputs controlled by the controller.
- D. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
 2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
- E. At completion, cable and asset management software shall reflect as-built conditions.

3.4 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.
- B. Coordinate database integration with Owner of each system.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.

2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.
3. Train personnel pursuant to 3.7 Demonstration.

3.6 PROTECTION

- A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 01 7900 "Demonstration and Training."
- B. Develop separate training modules for the following:
 1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
 2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
 3. Security personnel.
 4. Hardware maintenance personnel.
 5. Other administration staff, e.g. facilities director

END OF SECTION 28 1400

SECTION 28 1500 - ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Card readers, credential cards, and keypads
- 2. Access control peripheral devices
- 3. Electrified locking devices and accessories
- 4. Lockdown controls and signals
- 5. Cables
- 6. Transformers

- B. Related Requirements:

- 1. Section 08 7100 "Door Hardware" for information on power supply specifications and door sequence of operations.
- 2. Section 25 5000 "Integrated Automation Facility Controls" for integration with BMS/HVAC systems.
- 3. Section 28 1300 "Access Control System Software and Database Management" for control and monitoring applications, workstations, and interfaces.
- 4. Section 28 1523 "Intercom Entry Systems" for interface with intercom system.
- 5. Section 28 2000 "Video Surveillance" for integration with surveillance system.
- 6. Section 28 3100 "Fire Detection and Alarm" for integration with fire system.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

- 1. Device layout information, including the following:
 - a. Lockdown devices, including signal lights and initiation controls.
 - 1) Wiring diagrams indicating their connection to the access control system.
 - b. Initial wiring diagrams and connections between all devices requiring relays to/from the access control system, including:
 - 1) Access control release buttons and toggle switches
 - 2) Lockdown systems
 - 3) Dialing and signaling requirements on lockdown events
- 2. Initial access control programming schedules for unlock/lock times.
- 3. Diagrams for cable management system.

4. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
5. Wall plate options: provide cutsheets of all wall plate types for signal controls.
6. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
7. Cable Administration Drawings: As specified in "Identification" Article.
8. Battery and charger calculations for central station, workstations, and controllers.

C. Product Schedules.

- D. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.8 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient conditions of 60 to 85 deg F and a relative humidity of 20 to 80 percent, noncondensing.
2. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
3. Indoor, Uncontrolled Environment: NEMA 250, Type 4 enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0 to 122 deg F dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Outdoor Environment: NEMA 250, NEMA 250, Type 4X enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30 to plus 122 deg F dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 36 inches thick.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X enclosures.

PART 2 - PRODUCTS

2.1 OPERATION

- A. Security access system hardware shall use a single database for access-control and credential-creation functions.

2.2 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70, "National Electrical Code."
- C. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07.

2.3 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- A. Manufacturers: Refer to drawings for manufacturer and part number.
- B. Card Readers:
 1. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
 2. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.

3. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
 - a. Indoors, controlled environment.
 - b. Indoors, uncontrolled environment.
 - c. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
4. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
5. Stripe Swipe Readers: Bidirectional, reading cards swiped in both directions, powered by the controller. Reader shall be set up for ABA Track.
 - a. Readers for outdoors shall be in a polymeric plastic enclosure with all electronics potted in plastic. Rated for operation in ambient conditions of minus 40 to plus 160 deg F in a humidity range of 10 to 90 percent.
6. Wiegand Swipe Reader: Set up for 33 or 26-bit data cards. Comply with SIA AC-01.
7. Touch-Plate and Proximity Readers:
 - a. Active-detection proximity card readers shall provide power to compatible credential cards through magnetic induction, and shall receive and decode a unique identification code number transmitted from the credential card.
 - b. Passive-detection proximity card readers shall use a swept-frequency, RF field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
 - c. The card reader shall read proximity cards in a range from direct contact to at least 6 inches from the reader.

2.4 ACCESS CONTROL PERIPHERAL DEVICES

- A. Manufacturers: Refer to drawings for manufacturer and pat number.

2.5 CABLES

- A. General Cable Requirements: Comply with requirements in Section 27 0513 "Conductors and Cables for Communications Systems" and as recommended by system manufacturer for integration requirement.
- B. PVC-Jacketed, TIA 232-F.
 1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Polypropylene insulation.
 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 4. PVC jacket.
 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 6. Flame Resistance: Comply with UL 1581.
- C. Plenum-Rated TIA 232-F Cables:
 1. Nine, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. PE insulation.

3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
4. Fluorinated ethylene propylene jacket.
5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
6. Flame Resistance: Comply with NFPA 262.

D. PVC-Jacketed, TIA 485-A Cables:

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. NFPA 70 Type: Type CM.
6. Flame Resistance: Comply with UL 1581.

E. Plenum-Rated TIA 485-A Cables:

1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
2. Fluorinated ethylene propylene insulation.
3. Unshielded.
4. Fluorinated ethylene propylene jacket.
5. NFPA 70 Type: Type CMP
6. Flame Resistance: NFPA 262, Flame Test.

F. Multiconductor, PVC, Reader and Wiegand Keypad Cables:

1. No. 22 AWG, paired and twisted multiple conductors, stranded (7x30) tinned copper conductors, semirigid PVC insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CMG.
3. Flame Resistance: UL 1581 vertical tray.
4. For TIA 232-F applications.

G. Paired, PVC, Toggle Switch Button Cables:

1. Four pairs, No. 18 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 18 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CM.
3. Flame Resistance: UL 1581 vertical tray.

H. Paired, PVC, Reader and Wiegand Keypad Cables:

1. Three pairs, twisted, No. 20 AWG, stranded (7x28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded (19x34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CM.
3. Flame Resistance: UL 1581 vertical tray.

I. Paired, Plenum-Type, Reader and Wiegand Keypad Cables:

1. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum-foil/polypropylene-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

J. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cables:

1. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

K. LAN Cabling:

1. Comply with requirements in Section 27 1513 "Communications Copper Horizontal Cabling."

2.6 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.1 SPECIAL REQUIREMENTS

- A. At the exterior entry doors into common/shared space, ensure each card reader is connected to both Township Fire and Police systems.

3.2 INSTALLATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.3 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."

- B. Install cables and wiring according to requirements in Section 27 0513 "Conductors and Cables for Communications Systems."
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- E. Install LAN cables using techniques, practices, and methods that are consistent with Category 5e rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.
- F. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- G. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.4 CABLE APPLICATION

- A. Comply with TIA 569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. TIA 232-F Cabling: Install at a maximum distance of 50 ft. between terminations.
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. between terminations.
- E. Card Readers and Keypads:
 - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
 - 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 ft., and install No. 20 AWG wire if maximum distance is 500 ft..
 - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
 - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 500 ft. between terminations.
- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. between terminations.

3.5 GROUNDING

- A. Comply with Section 27 0526 "Grounding and Bonding for Communications Systems."
- B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Signal Ground:
 - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
 - 2. Bus: Mount on wall of main equipment room with standoff insulators.
 - 3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.6 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 27 0553 "Identification for Communications Systems" and with TIA 606-B.

3.7 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.
 - 2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.

3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

C. Devices and circuits will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

END OF SECTION 28 1500

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SECTION 28 3100 - FIRE DETECTION AND ALARM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section. Failure to consult these documents shall not relieve the Contractor of the requirements therein.

1.2 SUMMARY

- A. This Section includes fire alarm systems with manual stations, detectors, signal equipment, controls, and devices.
- B. Related Sections include the following:
 - 1. Division 08 Section "Door Hardware".
- C. Allowances: Allowances affect the Work of this Section. Refer to Division 01 Section "Allowances" for procedures for allowances.
 - 1. Allowance No. <Insert Number> - Fire Alarm Devices: Provide a lump sum allowance in the amount of [five thousand] <insert amount> dollars (\$[5000.00] <insert amount>) to cover the cost for additional fire alarm pull stations, smoke detectors or audio/visual signals required by the Authority Having Jurisdiction.

1.3 DEFINITIONS

- A. FACP: Fire alarm control panel.
- B. LED: Light-emitting diode.
- C. Definitions in NFPA 72 apply to fire alarm terms used in this Section.
- D. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

- A. General: Digital-addressable system with manual and automatic alarm initiation; automatic sensitivity control of certain smoke detectors; and multiplexed signal transmission dedicated to fire alarm service only.

1.5 SUBMITTALS

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

B. Shop Drawings:

1. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire alarm system design.
 - b. Fire alarm certified by NICET, minimum Level III.
2. Wiring Diagrams: Detail wiring and differentiate between manufacturer-installed and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified.
3. Battery: Sizing calculations.
4. Floor Plans: Indicate final outlet locations and routings of raceway connections.
5. Alarm Characteristics: Indicate the visual strobe candela and audible sound level requirements to satisfy NFPA 72 and the Authority having jurisdiction.
6. Device Address List: Coordinate with final system programming.
7. System Operation Description: Detailed description for this Project, including method of operation and supervision of each type of circuit and sequence of operations for manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are not acceptable.
8. Ductwork Coordination Drawings: Plans, sections, and elevations of ducts, drawn to scale and coordinating the installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, the detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
9. Voice/Alarm Signaling Service: Equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

C. Operating Instructions: For mounting at the FACP.

D. Installer Certificates: Signed by manufacturer certifying that installers comply with requirements.

E. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Comply with NFPA 72.

F. Maintenance Data: For fire alarm systems to include in maintenance manuals specified in Division 01. Comply with NFPA 72.

G. Submissions to Authorities Having Jurisdiction: In addition to distribution requirements for Submittals specified in Division 01 Section "Submittal Procedures," make an identical submission to authorities having jurisdiction, (Department of Labor & Economic Growth, Office of Fire Safety, P.O. Box 30254, Lansing, Michigan, 48909). Include copies of annotated Contract Drawings as needed to depict component locations to facilitate review. Resubmit if required to make clarifications or revisions to obtain approval. On receipt of comments from authorities having jurisdiction, submit them to Architect for review.

H. Certificate of Completion: Comply with NFPA 72.

I. Comply with NFPA 20 for fire pump installations.

J. Inspector's qualifications for the smoke control system.

K. Smoke control system's test results.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who is a trained and certified representative of the FACP manufacturer for both installation and maintenance of units required for this Project.
- B. Manufacturer Qualifications: A firm experienced in manufacturing systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. Source Limitations: Obtain fire alarm system components through one source from a single manufacturer.
- D. Compliance with Local Requirements: Comply with applicable building code, local ordinances and regulations, and requirements of authorities having jurisdiction.
- E. Comply with NFPA 72.

1.7 SEQUENCING AND SCHEDULING

- A. Existing Fire Alarm Equipment: Maintain fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of the new fire alarm system, remove existing disconnected fire alarm equipment and restore damaged surfaces.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Edwards Systems Technology; Unit of General Signal.
 - 2. Faraday, Inc.
 - 3. National Time and Signal Corporation.
 - 4. Notifier; a GE-Honeywell Company
 - 5. Siemens Building Technologies, Inc.; a Cerberus Division.
 - 6. Siemens Cerberus Pyrotronics.
 - 7. Federal Signal Corp.; Commercial Products Group.
 - 8. Fire Control Instruments, Inc.
 - 9. Fire Lite Alarms, Inc.
 - 10. Grinnell Fire Protection Systems.

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Control of System: By the FACP.

- B. System Supervision: Automatically detect and report open circuits, shorts, and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
- C. Priority of Signals: Automatic alarm response functions resulting from an alarm signal from one device are not altered by subsequent alarm, supervisory, or trouble signals. An alarm signal is the highest priority. Supervisory and trouble signals have second- and third-level priority. Higher-priority signals take precedence over signals of lower priority, even when the lower-priority condition occurs first. Annunciate and display all alarm, supervisory, and trouble signals regardless of priority or order received.
- D. Noninterference: A signal from one device shall not prevent the receipt of signals from other devices.
- E. System Reset: All devices are manually resettable from the FACP after initiating devices are restored to normal.
- F. Transmission to Remote Alarm Receiving Station: Automatically route alarm, supervisory, and trouble signals to a remote alarm station by means of a digital alarm communicator transmitter and telephone lines.
- G. System Alarm Capability during Circuit Fault Conditions: System wiring and circuit arrangement prevent alarm capability reduction when a single ground or open circuit occurs in an initiating device circuit, signal line circuit, or notification-appliance circuit.
- H. Loss of primary power at the FACP initiates a trouble signal at the FACP. The FACP indicates when the fire alarm system is operating on the secondary power supply.
- I. Basic Alarm Performance Requirements: Unless otherwise indicated, operation of a manual station, automatic alarm operation of a smoke or flame or heat detector, or operation of a sprinkler flow device initiates the following:
 - 1. Notification-appliance operation.
 - 2. Identification at the FACP and the remote annunciator of the device originating the alarm.
 - 3. Transmission of an alarm signal to the remote alarm receiving station.
 - 4. Unlocking of electric door locks in designated egress paths.
 - 5. Release of fire and smoke doors held open by magnetic door holders.
 - 6. Shutdown of fans and other air-handling equipment serving area when alarm was initiated.
 - 7. Closing of smoke dampers in air ducts of system serving area where alarm was initiated.
 - 8. Open normally closed contact tied to lighting control system to turn on emergency lighting.
 - 9. Recording of the event in the system memory.
- J. Alarm Silencing, System Reset and Indication: Controlled by switches in the FACP.
 - 1. Silencing-switch operation halts alarm operation of notification appliances and activates an "alarm silence" light. Display of identity of the alarm zone or device is retained.
 - 2. Subsequent alarm signals from other devices reactivate notification appliances until silencing switch is operated again.
- K. Water-flow alarm switch operation initiates the following:
 - 1. Notification-appliance operation.
 - 2. Flashing of the device location-indicating light for the device that has operated.

- L. Smoke detection for detectors with alarm verification initiates the following:
 - 1. Audible and visible indication of an "alarm verification" signal at the FACP.
 - 2. Activation of a listed and approved "alarm verification" sequence at the FACP and the detector.
 - 3. Recording of the event in the system memory.
 - 4. General alarm if the alarm is verified.
 - 5. Cancellation of the FACP indication and system reset if the alarm is not verified.
- M. Sprinkler valve-tamper switch operation initiates the following:
 - 1. A supervisory, audible, and visible "valve-tamper" signal indication at the FACP and the annunciator.
 - 2. Flashing of the device location-indicating light for the device that has operated.
 - 3. Recording of the event in the system memory.
 - 4. Transmission of supervisory signal to remote alarm receiving station.
- N. Fire-pump power failure, including a dead-phase or phase-reversal condition, initiates the following:
 - 1. A supervisory, audible, and visible "fire-pump power failure" signal indication at the FACP and the annunciator.
 - 2. Recording of the event in the system memory.
 - 3. Transmission of trouble signal to remote alarm receiving station.
- O. Fire-pump running condition, initiates the following:
 - 1. A supervisory, audible, and visible "fire-pump running" signal indication at the FACP and the annunciator.
 - 2. Recording of the event in the system memory.
 - 3. Transmission of trouble signal to remote alarm receiving station.
- P. Fire-pump alternate power supply condition, initiates the following:
 - 1. A supervisory, audible, and visible "alternate power source supplying fire-pump" signal indication at the FACP and the annunciator.
 - 2. Recording of the event in the system memory.
 - 3. Transmission of trouble signal to remote alarm receiving station.
- Q. Generator connection to system shall monitor and display the following:
 - 1. Generator in Fault Mode
 - 2. Generator in Manual Mode
 - 3. Generator is running
- R. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system initiates the following:
 - 1. A supervisory, audible, and visible "sprinkler trouble" signal indication at the FACP and the annunciator.
 - 2. Flashing of the device location-indicating light for the device that has operated.
 - 3. Recording of the event in the system memory.
 - 4. Transmission of trouble signal to remote central station.

- S. Remote Detector Sensitivity Adjustment: Manipulation of controls at the FACP causes the selection of specific addressable smoke detectors for adjustment, display of their current status and sensitivity settings, and control of changes in those settings. Same controls can be used to program repetitive, scheduled, automated changes in sensitivity of specific detectors. Sensitivity adjustments and sensitivity-adjustment schedule changes are recorded in system memory.
- T. Removal of an alarm-initiating device or a notification appliance initiates the following:
 - 1. A "trouble" signal indication at the FACP and the annunciator for the device or zone involved.
 - 2. Recording of the event in the system memory.
 - 3. Transmission of trouble signal to remote alarm receiving station.
- U. Printout of Events: On receipt of the signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble), and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including the same information for device, location, date, and time. Commands initiate the printout of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- V. FACP Alphanumeric Display: Plain-English-language descriptions of alarm, supervisory, and trouble events; and addresses and locations of alarm-initiating or supervisory devices originating the report. Display monitoring actions, system and component status, system commands, programming information, and data from the system's historical memory.

2.3 MANUAL PULL STATIONS

- A. Description: Fabricated of metal or plastic, and finished in red with molded, raised-letter operating instructions of contrasting color.
 - 1. Double-action mechanism requires two actions, such as a push and a pull, to initiate an alarm. Break glass/plastic stations are not acceptable.
 - 2. Station Reset: Key or wrench operated; double pole, double throw; switch rated for the voltage and current at which it operates.
 - 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. Integral Addressable Module: Arranged to communicate manual-station status (normal, alarm, or trouble) to the FACP.

2.4 SMOKE DETECTORS

- A. General: Include the following features:
 - 1. Operating Voltage: 24-V dc, nominal.
 - 2. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 3. Plug-in Arrangement: Detector and associated electronic components are mounted in a module that connects in a tamper-resistant manner to a fixed base with a twist-locking plug connection. Terminals in the fixed base accept building wiring.
 - 4. Integral Visual-Indicating Light: LED type. Indicates detector has operated.

5. Sensitivity: Can be tested and adjusted in-place after installation.
 6. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
 7. Remote Controllability: Unless otherwise indicated, detectors are analog-addressable type, individually monitored at the FACP for calibration, sensitivity, and alarm condition, and individually adjustable for sensitivity from the FACP.
- B. Photoelectric Smoke Detectors: Include the following features:
1. Sensor: LED or infrared light source with matching silicon-cell receiver.
 2. Detector Sensitivity: Between 2.5 and 3.5 percent/foot smoke obscuration when tested according to UL 268A.
 3. Integral Thermal Detector: Fixed-temperature type with 135 deg F setting.
- C. Beam-Type Smoke Detector: Each detector consists of a separate transmitter and receiver with the following features:
1. Adjustable Sensitivity: More than a six-level range, minimum.
 2. Linear Range of Coverage: 330 feet, minimum.
 3. Tamper Switch: Initiates trouble signal at the central FACP when either transmitter or receiver is disturbed.
 4. Separate Color-Coded LEDs: Indicate normal, alarm, and trouble status. Any detector trouble, including power loss, is reported to the central FACP as a composite "trouble" signal.
 5. Detectors with prism reflectors are not acceptable.
- D. Duct Smoke Detector: Photoelectric type.
1. Photoelectric Smoke Detectors:
 - a. Sensor: LED or infrared light source with matching silicon-cell receiver.
 - b. Detector Sensitivity: Between 2.5 and 3.5 percent/foot smoke obscuration when tested according to UL 268A.
 2. UL 268A listed, operating at 24-V dc, nominal.
 3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.
 4. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. The fixed base shall be designed for mounting directly to the air duct. Provide terminals in the fixed base for connection to building wiring.
 5. Self-Restoring: Detectors shall 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. **[Provide remote status and alarm indicator and test station where indicated.]**
 7. Sampling Tubes: Design and dimensions as recommended by manufacturer for the specific duct size, air velocity, and installation conditions where applied.
 8. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit. Motor shutdown wiring by Temperature Control Supplier.

2.5 OTHER DETECTOR

- A. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F or rate of rise of temperature that exceeds 15 deg F per minute, unless otherwise indicated.
1. Mounting: Plug-in base, interchangeable with smoke detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the FACP.

2.6 NOTIFICATION APPLIANCES

- A. Description: Equip for mounting as indicated and have screw terminals for system connections.
1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly.
- B. Chimes, High-Level Output: Vibrating type, 81 dB minimum rated output.
- C. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Horns produce a sound-pressure level of 90 dB, measured 10 feet from the horn. Beige or Ivory color.
1. Where installed in sleeping areas, provide square wave signal with fundamental frequency of 520 Hz +/- 10% per NFPA-72
- D. Visible Alarm Devices: Xenon strobe lights listed under UL 1971 with clear or nominal white polycarbonate lens. Mount lens on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch high letters on the lens. Beige or Ivory color.
1. Rated Light Output: 15, 30, 75, or 110 candela, as required to satisfy NFPA 72 requirements.
 2. Strobe Leads: Factory connected to screw terminals.
 3. Strobes shall be synchronized.
- E. Voice/Tone Speakers:
1. High-Range Units: Rated 2 to 15 W.
 2. Low-Range Units: Rated 1 to 2 W.
 3. Mounting: Flush, semirecessed, surface, or surface-mounted; bi-directional as indicated.
 4. Matching Transformers: Tap range matched to the acoustical environment of the speaker location.
- F. Fire Connection Strobe: Provide all required connections to the strobe/horn associated with the fire fighters hose connection on the exterior of the building. Provide 120V power from nearest panel for devices provided by sprinkler system supplier. Connect to emergency power when available.

2.7 REMOTE DEVICE LOCATION-INDICATING LIGHTS AND IDENTIFICATION PLATES

- A. Description: LED indicating light near each smoke detector that may not be readily visible, and each sprinkler water-flow switch and valve-tamper switch. Light is connected to flash when the associated device is in an alarm or trouble mode. Lamp is flush mounted in a single gang wall plate. A red, laminated, phenolic-resin identification plate at the indicating light identifies, in engraved white letters,

device initiating the signal and room where the smoke detector or valve is located. For water-flow switches, the identification plate also designates protected spaces downstream from the water-flow switch.

2.8 MAGNETIC DOOR HOLDERS

- A. Provide wiring for magnetic door holders furnished and installed by the door hardware contractor.

2.9 PROGRAMMER/TESTOR

- A. Provide a programmer/testor for any fire alarm system requiring such a device for programming and maintenance of signal initiation devices. Furnish unit complete with carrying case and instructions.

2.10 CENTRAL FACP

- A. Cabinet: Lockable steel enclosure. Arrange interior components so operations required for testing or for normal maintenance of the system are performed from the front of the enclosure. If more than one unit is required to form a complete control panel, fabricate with matching modular unit enclosure to accommodate components and to allow ample gutter space for field wiring and interconnecting panels.
 - 1. Identify each enclosure with an engraved, red, laminated, phenolic-resin nameplate with lettering not less than 1 inch high. Identify individual components and modules within cabinets with permanent labels.
 - 2. Mounting: Flush.
- B. Alarm and Supervisory Systems: Separate and independent in the FACP. Alarm-initiating zone boards consist of plug-in cards. Construction requiring removal of field wiring for module replacement is unacceptable.
- C. Control Modules: Include types and capacities required to perform all functions of fire alarm systems. Provide 20% spare signal capacity for future alarm devices.
- D. Indications: Local, visible, and audible signals announce alarm, supervisory, and trouble conditions. Each type of audible alarm has a different sound.
- E. Resetting Controls: Prevent the resetting of alarm, supervisory, or trouble signals while the alarm or trouble condition still exists.
- F. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 - 1. Display: Liquid-crystal type, 40 (small projects) or 80 (large projects) characters, minimum.
 - 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- G. Alphanumeric Display and System Controls: Arranged for interface between human operator at the FACP and addressable system components, including annunciation, supervision, and control.

1. Display: A minimum of 80 characters; alarm, supervisory, and component status messages; and indicate control commands to be entered into the system for control of smoke detector sensitivity and other parameters.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- H. Instructions: Printed 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.
- 2.11 NOTIFICATION APPLIANCE CIRCUIT (NAC) EXTENDER PANELS
- A. Provide NAC panels as required to support notification appliances.
 - B. Provide layout of proposed NAC panel locations prior to installation.
- 2.12 REMOTE ANNUNCIATOR
- A. Description: Duplicate annunciator functions of the FACP for alarm, supervisory, and trouble indications. Also duplicate manual switching functions of the FACP, including acknowledging, silencing, reset, and test.
 1. Mounting: Flush cabinet, NEMA 250, Class 1.
 - B. Display Type and Functional Performance: Alphanumeric display same as the FACP. Controls with associated LEDs permit acknowledging, silencing, resetting, and testing functions for alarm, supervisory, and trouble signals identical to those in the FACP.
 - C. Where main FACP is installed in electrical room, remote annunciator panel shall be capable of making voice announcements.
- 2.13 FIREFIGHTER'S SMOKE CONTROL STATION
- A. Firefighters Smoke Control Station (FSCS): shall provide full monitoring and manual control capability over all smoke-control/evacuation systems and equipment. The FSCS shall be furnished by the fire alarm system manufacturer. The FSCS shall have the highest priority control over all smoke-control systems and equipment and shall override or bypass other building controls such as Hand-Off-Auto switches and On-Off switches. The FSCS shall depict graphically the physical building arrangement, smoke-control systems and equipment and the areas served by the equipment. Provide all equipment required for complete operation of the smoke control system including but not limited to conduit, wire and interface devices. System shall include the following:
 1. Control panel shall be semi-flush mounting with a maximum panel width of 24 inches.
 2. Operable controls shall be placed behind a lockable see-through door.
 3. Graphic panel with pilot lamps and switches.
 4. Provide a pilot lamp test switch to test all lamps on the panel.
 5. All lamps shall be LED type.
 6. Panel shall be UL Listed as a Firefighters Smoke Control Station under UL864-UUKL for smoke control.

- B. Smoke Control System: Fans within the building shall be shown on the FSCS. A clear indication of the direction of the airflow and the relationship of the components shall be displayed. Status indicators shall be provided for all smoke control equipment, annunciated by fan and zone and by pilot lamp type indicators as follows:
1. Fans, dampers, and other operating equipment in their normal status – White.
 2. Fans, dampers, and other operating equipment in their off or closed status – Red.
 3. Fans, dampers, and other operating equipment in their on or open status – Green.
 4. Fans, dampers, and other operating equipment in a fault status – Yellow/Amber.
- C. Features: The FSCS shall provide control capability over the complete smoke control system equipment within the building as follows:
1. On-Auto-Off control over each individual piece of operating smoke control equipment that can also be controlled from other sources within the building. This includes stairway pressurization fans; smoke exhaust fans; supply, return and exhaust fans; elevator shaft fans; and other operating equipment used or intended for smoke control purposes.
 2. Open-Auto-Close control over individual dampers related to smoke control and that are also controlled from other sources within the building.
 3. On-Off or Open-Close control over smoke control and other critical equipment associated with a fire or smoke emergency and that can only be controlled from the FSCS.
- D. Acceptance Testing: Devices, equipment, components and sequences shall be individually tested. These tests shall consist of determination of function, sequence and capacity of their installed condition. Tests shall include:
1. Detection devices.
 2. Ducts.
 3. Dampers.
 4. Inlet and outlets.
 5. Fans.
 6. Smoke barriers.
 7. Controls.
- E. Special Inspections for Smoke Control: Smoke control systems shall be tested by a third party, special inspector as part of this contract.
1. Qualifications: Special inspection agencies for smoke control shall have experience in fire protection engineering, mechanical, engineering and certification as air balancers.
 2. Reports: A complete report of testing shall be provided by the special inspector. The report shall include identification of all devices by manufacturer, nameplate data, design values, measured values and identification tag or mark.
 3. Report Filing: A copy of the final report shall be filed with the fire code official and a copy shall be maintained in the building.

2.14 EMERGENCY POWER SUPPLY

- A. General: Components include lead acid battery, charger, and an automatic transfer switch.
1. Battery Nominal Life Expectancy: 20 years, minimum.

- B. Battery Capacity: Comply with NFPA 72.
 - 1. Magnetic door holders are not served by emergency power. Magnetic door holders are released when normal power fails.
- C. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Provide capacity for 150 percent of the connected system load while maintaining batteries at full charge. If batteries are fully discharged, the charger recharges them completely within four hours. Charger output is supervised as part of system power supply supervision.
- D. Integral Automatic Transfer Switch: Transfers the load to the battery without loss of signals or status indications when normal power fails.

2.15 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module listed for use in providing a multiplex system address for listed fire and sprinkler alarm-initiating devices with normally open contacts.

2.16 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Listed and labeled under UL 864 and NFPA 72.
- B. Functional Performance: Unit receives an alarm, supervisory, or trouble signal from the FACP panel, and automatically captures one or two telephone lines and dials a preset number for a remote central station. When contact is made with the central station(s), the signal is transmitted. The unit supervises up to two telephone lines. Where supervising two lines, if service on either line is interrupted for longer than 45 seconds, the unit initiates a local trouble signal and transmits a signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. When telephone service is restored, unit automatically reports that event to the central station. If service is lost on both telephone lines, the local trouble signal is initiated.
- C. Contractor to confirm with other trades or owner the type of transmitter to provide. Provide Voice Over IP type dialler in installations where VOIP systems are in place.
- D. Secondary Power: Integral rechargeable battery and automatic charger. Battery capacity is adequate to comply with NFPA 72 requirements.
- E. Self Test: Conducted automatically every 24 hours with report transmitted to central station.

2.17 GUARDS FOR PHYSICAL PROTECTION

- A. Description: Welded wire mesh of size and shape for the manual stations, smoke detectors, and audio/visual devices located in school gymnasiums, multi-purpose rooms and locker rooms.
 - 1. Factory fabricated and furnished by the manufacturer of the device.
 - 2. Finish: Paint of color to match the protected device.

2.18 WIRE

- A. Non-Power-Limited Circuits: Copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum.
- B. Power-Limited Circuits: NFPA 70, Types FPL, FPLR, or FPLP, as recommended by manufacturer.

2.19 GENERATOR CONNECTION

- A. Provide connection to emergency generator system and provide status as indicated in the fire alarm control panel section.

2.20 BREAKER LOCK DEVICE

- A. Provide breaker circuit lockout device on branch circuits feeding any fire alarm equipment including fire alarm panels and NAC panels. Utilize Elock fire alarm circuit lockout kit #ELOCK-FA and a red placard indicating "FIRE ALARM / EMERGENCY CIRCUIT INSIDE".

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Install fire alarm system in accordance with manufacturer's installation drawings and instructions.
- B. Connecting to Existing Equipment: Verify that existing fire alarm system is operational before making changes or connections.
 - 1. Connect new equipment to the existing control panel in the existing part of the building.
 - 2. Expand, modify, and supplement the existing control equipment as necessary to extend the existing control functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
- C. Manual Pull Stations: Mount semiflush in recessed back boxes.
- D. Water-Flow Detectors and Valve Supervisory Switches: Connection for each sprinkler valve station required to be supervised.
- E. Ceiling-Mounted Smoke Detectors: Not less than 4 inches from a side wall to the near edge. For exposed solid-joist construction, mount detectors on the bottom of joists. On smooth ceilings, install not more than 30 feet apart in any direction.
- F. Wall-Mounted Smoke Detectors: At least 4 inches, but not more than 12 inches, below the ceiling.
- G. Smoke Detectors near Air Registers: Install no closer than 60 inches.
- H. Duct Smoke Detectors: Comply with manufacturer's written instructions.

1. Verify that each unit is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
2. Install sampling tubes so they extend the full width of the duct.
- I. Audible Alarm-Indicating Devices: Install chimes and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Combine audible and visible alarms at the same location into a single unit.
- J. Visible Alarm-Indicating Devices: Install adjacent to each alarm chime or alarm horn.
- K. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- L. Horn/strobe at Fire Fighter's Hose Connection: Connect horn/strobe located on the exterior of the building associated with the sprinkler system.
- M. FACP: Surface mount with tops of cabinets not more than 72 inches above the finished floor.
- N. Annunciator: Install with the top of the panel not more than 60 inches above the finished floor.
- O. Provide smoke detectors where required for all FACP and NAC panels.
- P. Provide power to all FACP and NAC panels. Connect to emergency power when available.

3.2 WIRING INSTALLATION

- A. Install wiring according to the following:
 1. NECA 1.
 2. TIA/EIA 568-A.
- B. **[Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceway and Boxes for Electrical Systems."**
 1. **Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.]**
- C. Wiring Method:
 1. Install wiring in raceways except in accessible ceiling spaces and in gypsum-board partitions where cable wiring method may be used. Route the fire alarm cable in cable tray system when available. Wiring run in ceiling space where there is no tray or conduit, support independently of other systems with dedicated low voltage rings / hooks. No zip ties or support from other systems or conduits allowed.
 2. Conceal cables and raceways except in unfinished spaces.
 3. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 4. Fire-Rated Cables: Use of 2-hour fire-rated fire alarm cables, NFPA 70 Types MI and CI, is not permitted.
 5. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

- D. **[Wiring Method: Fire alarm systems that interface with smoke control systems shall have all wiring, regardless of voltage, installed in continuous raceways.]**
- E. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by the manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- F. Cable Taps: Use numbered terminal strips in junction, pull and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- G. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- H. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signal from other floors.
- I. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the FACP and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.
- J. Provide handle clamps on all circuit breakers feeding fire alarm system components. Handle clamps shall lock the circuit breaker in the "ON" position.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals according to Division 26 Section Identification for Electrical Systems."
- B. Install instructions frame in a location visible from the FACP.
- C. Install circuit breaker lockout kit and plackard on panels indicating where emergency fire alarm circuits are fed from.

3.4 GROUNDING

- A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a #8 AWG ground wire from main service ground to the FACP.
- B. Ground cable shields and equipment according to system manufacturer's written instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

- D. Install grounding electrodes of type, size, location, and quantity as indicated. Comply with installation requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common-mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and connections and to supervise pretesting, testing, and adjustment of the system. Report results in writing.
- B. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the compliance of the system with requirements of Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones, and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of witnesses to preliminary tests.
- D. Final Test Notice: Provide a minimum of 10 days' notice in writing when the system is ready for final acceptance testing.
- E. Minimum System Tests: Test the system according to procedures outlined in NFPA 72. Minimum required tests are as follows:
 - 1. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 2. Test all conductors for short circuits using an insulation-testing device.
 - 3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on record drawings.
 - 4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.
 - 5. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
 - 6. Test each initiating and indicating device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.
 - 7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.
 - 8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.
 - 9. **[Test smoke control operation startup and shutdown.]**

- F. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log on the satisfactory completion of tests.
- H. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.
- I. Provide certification of the fire alarm installation. Submit required documents to the Michigan Department of Labor & Economic Growth, Office of Fire Safety.

3.6 CLEANING AND ADJUSTING

- A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

3.7 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, adjusting, and maintaining equipment and schedules. Provide a minimum of 8 hours' training.
 - 2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.
 - 3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

3.8 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to three requested visits to Project site for this purpose.

END OF SECTION 28 3100

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SECTION 31 1000 - SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Protecting existing trees, shrubs, groundcover, plants, and grass to remain.
2. Clearing and grubbing.
3. Stripping and stockpiling topsoil.
4. Removing above- and below-grade site improvements.
5. Disconnecting and capping or sealing site utilities.
6. Temporary erosion and sedimentation control measures.

B. Related Sections include the following:

1. Division 01 Section "Temporary Tree and Plant Protection" for protecting trees remaining on-site that are affected by site operations.
2. Division 31 Section "Earth Moving" for soil materials, excavating, backfilling, and site grading.
3. Division 32 Section "Turf and Grasses" for finish grading including preparing and placing planting soil mixes and testing of topsoil material.

1.2 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.
- B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.3 MATERIAL OWNERSHIP

- A. Except for stripped topsoil or other materials indicated to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.4 SUBMITTALS

- A. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.
- B. Record drawings, according to Division 1 Section "Project Record Documents," identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.5 QUALITY ASSURANCE

- A. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 1 Section "Project Management and Coordination."

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 authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.
 - 1. Do not proceed with work on adjoining property until directed by Architect.
- C. Salvable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises where indicated.
- D. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. Satisfactory Soil Materials: Requirements for satisfactory soil materials are specified in Division 31 Section "Earth Moving."
 - 1. Obtain approved borrow soil materials off-site when satisfactory soil materials are 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 flag trees and vegetation to remain or to be relocated.
- C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 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 requirements of authorities having jurisdiction.
- B. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.
- C. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE PROTECTION

- A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.
 1. Do not store construction materials, debris, or excavated material within fenced area.
 2. Do not permit vehicles, equipment, or foot traffic within fenced area.
 3. Maintain fenced area free of weeds and trash.
- B. Do not excavate within tree protection zones, unless otherwise indicated.
- C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.
 1. Cover exposed roots with burlap and water regularly.
 2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
 3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
 4. Backfill with soil as soon as possible.
- D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by Architect.

3.4 UTILITIES

- A. Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.
 1. Verify that utilities have been disconnected and capped before proceeding with site clearing.
- B. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.
 1. Arrange with utility companies to shut off indicated utilities.
 2. Owner will arrange to shut off indicated utilities when requested by Contractor.

- C. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
- D. Excavate for and remove underground utilities indicated to be removed.
- E. Removal of underground utilities is included in Division 33 Sections covering site utilities.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, grass, 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. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
 - 3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
 - 4. Use only hand methods for grubbing within tree protection zone.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust.
 - 1. Limit height of topsoil stockpiles to 72 inches.
 - 2. Do not stockpile topsoil within tree protection zones.
 - 3. Dispose of excess topsoil as specified for waste material disposal.
 - 4. Stockpile surplus topsoil to allow for resspreading deeper topsoil.

3.7 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and as 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 length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.

2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.8 DISPOSAL

- A. Disposal: 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.
 1. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.
 2. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

END OF SECTION 31 1000

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SECTION 31 2000 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Preparing subgrades for walks, pavements, lawns and grasses, and exterior plants.
2. Excavating and backfilling for buildings and structures.
3. Drainage course for slabs-on-grade.
4. Subbase course for concrete walks, and pavements.
5. Subbase and base course for asphalt paving.
6. Excavating and backfilling for utility trenches.

B. Related Sections include the following:

1. Division 31 Section "Site Clearing" for temporary erosion and sedimentation control measures, site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements and utilities.
2. Division 33 Section "Subdrainage" for drainage of foundations, slabs-on-grade, walls, and landscaped areas.
3. Division 33 Section "Turf and Grasses" for finish grading, including preparing and placing topsoil and planting soil for lawns.
4. Division 33 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures.

C. Unit Prices: The Work of this Section is affected by Unit Prices. Refer to Division 1 Section "Unit Prices" for general requirements applicable to unit prices.

1. Unit Price 1: Supplemental Excavation, Satisfactory Soil Fill: Unit price for unforeseen excavation due to unsatisfactory soil conditions and replacement with satisfactory soil. Unit of measurement shall be cubic yard.
2. Unit Price 2: Supplemental Excavation, Engineered Fill: Unit price for unforeseen excavation due to unsatisfactory soil conditions and replacement with engineered fill. Unit of measurement shall be cubic yard.

1.2 DEFINITIONS

A. Backfill: Soil 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: Course placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Course 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: Course supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
- F. Excavation: Removal of material encountered below subgrade elevations and to lines and dimensions indicated.
 - 1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions changes in the Work.
 - 2. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.
- G. Fill: Soil materials used to raise existing grades.
- H. Tested by an independent geotechnical testing agency, according to ASTM D 1586.
- I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- J. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a concrete slab-on-grade, cement concrete pavement, or a cement concrete or hot-mix asphalt walk.
- K. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.
- L. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Each type of plastic warning tape.
 - 2. Geotextile.
 - 3. Controlled low-strength material, including design mixture.
 - 4. Geofoam.
- B. Samples: 12-by-12-inch Sample of geotextile.

1.4 PROJECT CONDITIONS

- A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted in writing by Construction Manager and Owner and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Construction Manager and Owner not less than two days in advance of proposed utility interruptions.
 2. Do not proceed with utility interruptions without Construction Manager's written permission.
 3. Contact utility-locator service for area where Project is located before excavating.
- B. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Satisfactory Soils: ASTM D 2487 Soil Classification Groups GW, GP, GM, SW, SP, and SM, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- D. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
- E. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups.
1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
- F. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- G. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.
- H. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.
- I. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

- J. Drainage Course: Narrowly graded mixture of washed, crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and 0 to 5 percent passing a No. 8 sieve.
- K. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and 0 to 5 percent passing a No. 4 sieve.
- L. Sand: ASTM C 33; fine aggregate, natural, or manufactured sand.
- M. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

- A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288.
 - 2. Grab Tensile Strength: 157 lbf ; ASTM D 4632.
 - 3. Sewn Seam Strength: 142 lbf ; ASTM D 4632.
 - 4. Tear Strength: 56 lbf ; ASTM D 4533.
 - 5. Puncture Strength: 56 lbf ; ASTM D 4833.
 - 6. Apparent Opening Size: No. 40 sieve, maximum; ASTM D 4751.
 - 7. Permittivity: 0.5 per second, minimum; ASTM D 4491.
 - 8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
- B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
 - 1. Survivability: Class 2; AASHTO M 288.
 - 2. Grab Tensile Strength: 247 lbf ; ASTM D 4632.
 - 3. Sewn Seam Strength: 222 lbf ; ASTM D 4632.
 - 4. Tear Strength: 90 lbf ; ASTM D 4533.
 - 5. Puncture Strength: 90 lbf ; ASTM D 4833.
 - 6. Apparent Opening Size: No. 60 sieve, maximum; ASTM D 4751.
 - 7. Permittivity: 0.02 per second, minimum; ASTM D 4491.
 - 8. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

- A. Controlled Low-Strength Material: Low-density, self-compacting, flowable concrete material as follows:
 - 1. Portland Cement: ASTM C 150, Type I.
 - 2. Portland Cement: ASTM C 150, Type I, II, or III.
 - 3. Fly Ash: ASTM C 618, Class C or F.
 - 4. Normal-Weight Aggregate: ASTM C 33, 3/4-inch nominal maximum aggregate size.
 - 5. Normal-Weight Aggregate: ASTM C 33, Insert dimension nominal maximum aggregate size.

6. Foaming Agent: ASTM C 869.
7. Water: ASTM C 94/C 94M.
8. Air-Entraining Admixture: ASTM C 260.

B. Produce low-density, controlled low-strength material with the following physical properties:

1. According to ASTM C 495.

C. Produce conventional-weight, controlled low-strength material with 140-psi compressive strength when tested according to ASTM C 495.

2.4 ACCESSORIES

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

1. 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 earthwork operations.
- B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Division 31 Section "Site Clearing."
- C. Protect and maintain erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing," during earthwork operations.
- D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system specified in Division 31 Section "Dewatering," to keep subgrades dry and convey ground water away from excavations. Maintain until dewatering is no longer required.

3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.
- B. Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.
 1. Perform blasting without damaging adjacent structures, property, or site improvements.
 2. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

3.4 EXCAVATION

- 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.
- B. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract time may be authorized for rock excavation.
 1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
 - a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.
 2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:

3.5 EXCAVATION FOR STRUCTURES

- A. Excavation for Structures: 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: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Pile Foundations: Stop excavations 6 to 12 inches above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavation for Walks and Pavements: Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

- A. Excavation for Utility Trenches: 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.
 2. 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.
 - a. Clearance: As indicated.
 - b. Clearance: 12 inches each side of pipe or conduit.
 3. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
 - a. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material, 4 inches deeper elsewhere, to allow for bedding course.

3.8 SUBGRADE INSPECTION

- A. Proof-roll subgrade below the building slabs and 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 15 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.
- B. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.9 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi , may be used when approved by Architect.
 - 1. Fill unauthorized excavations under other construction or utility pipe as directed by Architect.

3.10 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.

3.11 BACKFILL

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

3.12 UTILITY TRENCH BACKFILL

- A. Utility Trench Backfill: Place backfill on subgrades free of mud, frost, snow, or ice.
 - 1. 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.
 - 2. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03 Section "Cast-in-Place Concrete."
 - 3. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 3 Section "Cast-in-Place Concrete."
 - 4. Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.
 - 5. Place and compact initial backfill of subbase material, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

- a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
6. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the utility pipe or conduit.
7. Backfill voids with satisfactory soil while installing and removing shoring and bracing.
8. Place and compact final backfill of satisfactory soil to final subgrade elevation.
9. Controlled Low-Strength Material: Place final backfill of controlled low-strength material to final subgrade elevation.
10. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.13 SOIL FILL

- A. Soil Fill: Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material. 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 engineered fill.
 4. Under building slabs, use engineered fill.
 5. Under footings and foundations, use engineered fill.

3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
 1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
 2. Remove and replace, or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.15 COMPACTION OF SOIL BACKFILLS AND FILLS

- A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.
- B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698:
 1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at [95] <Insert percentage> percent.

2. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at 95 percent.
 - a. Under slabs on grade, place 6 inches compacted depth of sand
3. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 92 percent.
4. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at [92] <Insert percentage> percent.
5. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 90 percent.
6. Under lawn or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at [85] <Insert percentage> percent.
7. For utility trenches, compact each layer of initial and final backfill soil material at 95 percent.
8. For utility trenches, compact each layer of initial and final backfill soil material at [85] <Insert percentage> percent.

3.16 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.
- B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
 1. Lawn or Unpaved Areas: Plus or minus 1 inch .
 2. Walks: Plus or minus ¼ 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.

3.17 SUBSURFACE DRAINAGE

- A. Subdrainage Pipe: Specified in Division 33 Section "Subdrainage."
- B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches .
 1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698.
 2. Compact each filter material layer [to 85 percent of maximum dry unit weight according to ASTM D 698] [with a minimum of two passes of a plate-type vibratory compactor].
 3. Extend filter material at footing drain to foundation drainage panel.
- C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches.

1. Compact each filter material layer [to 85 percent of maximum dry unit weight according to ASTM D 698] [with a minimum of two passes of a plate-type vibratory compactor].
2. Place and compact impervious fill over drainage

3.18 SUBBASE AND BASE COURSES

- A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place subbase and base course under pavements and walks as follows:
 1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 2. Place base course material over subbase course under hot-mix asphalt pavement.
 3. Shape subbase and base course to required crown elevations and cross-slope grades.
 4. Place subbase and base course 6 inches or less in compacted thickness in a single layer.
 5. Place subbase and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 6. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698.
- C. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698.

3.19 DRAINAGE COURSE

- 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 and at footing drains as follows:
 1. Place drainage course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
 2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.
 3. Compact each layer of drainage course to required cross sections and thicknesses to not less than [95] <Insert percentage> percent of maximum dry unit weight according to ASTM D 698.

3.20 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.
- B. Testing Agency: Engage a qualified independent geotechnical engineering testing agency to perform field quality-control testing.

- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.
- 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 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every 2000 sq. ft. or less of paved area or building slab, but in no case fewer than 3 tests.
 - 2. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least 1 test for every Insert area or less of paved area or building slab, but in no case fewer than 3 tests.
 - 3. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each 100 feet or less of wall length, but no fewer than 2 tests.
 - 4. Foundation Wall Backfill: At each compacted backfill layer, at least 1 test for each Insert dimension or less of wall length, but no fewer than 2 tests.
 - 5. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each 150 feet or less of trench length, but no fewer than 2 tests.
 - 6. Trench Backfill: At each compacted initial and final backfill layer, at least 1 test for each Insert dimension or less of trench length, but no fewer than 2 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 to depth required; recompact and retest until specified compaction is obtained.

3.21 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.
- 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.
- D. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off Owner's property.

END OF SECTION 31 2000

SECTION 31 3116 - TERMITE CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes: Soil treatment with termiticide.
- B. Related Sections:
 - 1. Section 06 1000 "Rough Carpentry" for wood preservative treatment by pressure process.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include the EPA-Registered Label for termiticide products.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Product certificates.
- C. Soil Treatment Application Report: 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.

1.4 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 for each product.

1.5 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.

1.6 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.

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: Under ground-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.
 3. Masonry: Treat voids.
 4. Penetrations: At expansion joints, control joints, and areas where slabs will be penetrated.
- 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 31 3116

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SECTION 32 1216 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing hot-mix asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt paving overlay.
5. Pavement-marking paint.

B. Related Sections:

1. Division 31 Section "Earth Moving" for aggregate subbase and base courses and for aggregate pavement shoulders.
2. Division 32 Section "Concrete Paving Joint Sealants" for joint sealants and fillers at paving terminations

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

1. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
2. Job-Mix Designs: For each job mix proposed for the Work.

B. Material Certificates: For each paving material, from manufacturer.

1.3 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by the Michigan Department of Transportation.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of Michigan Department of Transportation for asphalt paving work.

1.4 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. Tack Coat: Minimum surface temperature of 60 deg F.

2. Asphalt Base Course: Minimum surface temperature of 40 deg F and rising at time of placement.
 3. 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. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- B. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
- C. Mineral Filler: ASTM D 242, rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, PG 64-22.
- B. Tack Coat: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

2.3 AUXILIARY MATERIALS

- A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.
- B. Pavement-Marking Paint: MPI #97 Latex Traffic Marking Paint.
 1. Color: Yellow stripes and Blue for barrier free

2.4 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by Michigan Department of Transportation and complying with the following requirements:
 1. Base Course: as indicated
 2. Surface Course: as indicated:

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify 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.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 COLD MILLING

- A. Cleaning existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.

3.3 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. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
 - 1. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.
- C. 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.
- D. Patching: Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

3.4 SURFACE PREPARATION

- A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

- B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
- C. Tack Coat: Apply uniformly to surfaces of existing pavement 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.

3.5 HOT-MIX ASPHALT PLACING

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
 - 1. Spread mix at minimum temperature of 250 deg F.
 - 2. 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.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.6 JOINTS

- A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
 - 1. Clean contact surfaces and apply tack coat 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."

3.7 COMPACTION

- A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or 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: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
- G. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.8 ASPHALT CURBS

- A. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of 250 deg F.
 - 1. Asphalt Mix: Same as pavement surface-course mix.
- B. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.

3.9 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. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.10 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 3 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.
 - 1. Broadcast glass beads uniformly into wet pavement markings at a rate of 6 lb/gal..

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Replace and compact hot-mix asphalt where core tests were taken.
- C. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.12 DISPOSAL

- A. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.

END OF SECTION 32 1216

SECTION 32 1313 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Curbs and gutters.
2. Walkways.

B. Related Sections include the following:

1. Division 3 Section "Cast-in-Place Concrete" for general building applications of concrete.
2. Division 31 Section "Earth Moving" for subgrade preparation, grading, and subbase course.
3. Division 32 Section "Pavement Joint Sealants" for joint sealants of joints in concrete pavement and at isolation joints of concrete pavement with adjacent construction.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Design Mixtures: For each concrete pavement mixture.
- C. Material Certificates: Signed by manufacturers certifying that each material complies with requirements:
- D. Minutes of preinstallation conference.

1.3 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
- B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.
- C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.
- D. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.
- E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."
1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction

practices. Require representatives of each entity directly concerned with concrete pavement, to attend conference:

1.4 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

1.5 LOCAL REQUIREMENTS

- A. All improvements in the proposed public right-of-way shall comply with the City of Portage Standard Specifications, current edition and the 2012 MDOT Standard Specifications for Construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Products: Subject to compliance with requirements, provide one of the products specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
 - 1. Use flexible or curved forms for curves with a radius 100 feet or less.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

2.3 STEEL REINFORCEMENT

- A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.
- B. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.
- C. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60. Cut bars true to length with ends square and free of burrs.
- D. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.

- E. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice."

2.4 CONCRETE MATERIALS

- A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:
 - 1. Portland Cement: ASTM C 150, white portland cement Type I. Supplement with the following:
 - a. Fly Ash: ASTM C 618, Class C or F.
 - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
- B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source with documented service record data of at least 10 years' satisfactory service in similar pavement applications and service conditions using similar aggregates and cementitious materials.
 - 1. Coarse Aggregate: MDOT 6A or MDOT 6AA.
 - 2. Maximum Coarse-Aggregate Size: 1-1/2 inches nominal.
 - 3. Fine Aggregate: MDOT 2NS.
 - 4. Do not use fine or coarse aggregates containing substances that cause spalling.
- C. Water: ASTM C 94/C 94M.
- D. Air-Entraining Admixture: ASTM C 260.
- E. Chemical Admixtures: ASTM C 494/C 494M, of type suitable for application, certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

2.5 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth.
- B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
- E. White, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.

2.6 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.

- B. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- C. Penetrating Liquid Slab Treatment: Chemically reactive, waterborne solution of inorganic silicate or silicate materials and proprietary components; odorless; colorless; that penetrates, hardens, and densifies concrete surfaces.
 - 1. Products:
 - a. Chemisil Plus; ChemMasters.
 - b. Day-Chem Sure Hard; Dayton Superior Corporation.
 - c. Euco Diamond Hard; Euclid Chemical Co.
 - d. Seal Hard; L&M Construction Chemicals, Inc.

2.7 CONCRETE MIXTURES

- A. Prepare design mixtures, proportioned according to ACI 301, with the following properties:
 - 1. Compressive Strength (28 Days): 4000 psi].
 - 2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.
 - 3. Slump Limit: 4 inches, plus or minus 1 inch.
 - 4. Air Content: 5-1/2 percent plus or minus 1.5 percent.

2.8 CONCRETE MIXING

- A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.
 - 1. When air temperature is between 85 deg F 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.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

- A. 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 loaded 10-wheel tandem-axle dump truck weighing not less than 15 tons.
 - 3. Subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch require correction according to requirements in Division 31 Section "Earth Moving."

3.2 INSTALLATION

3.3 EDGE FORMS AND SCREED CONSTRUCTION

- A. Edge Forms and Screed Construction: Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement 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.

1. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT

- A. Steel Reinforcement: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

1. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
2. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.5 JOINTS

- A. Joints, 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.

- 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 pavement strips, unless otherwise indicated.
2. Provide tie bars at sides of pavement strips where indicated.

- 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. Protect top edge of joint filler during concrete placement 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, to match jointing of existing adjacent concrete paving.
 - 1. Sawed Joints with beveled edge for hand tooled look or hand tool 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. Bevel sawcut with beveled blade for tooled look.
- 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.

3.6 CONCRETE PLACEMENT

- A. Concrete Placement: Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.
 - 1. Moisten subbase to provide a uniform dampened condition at time concrete is placed.
 - 2. Do not add water to fresh concrete after testing.
 - 3. 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.
 - 4. Screed pavement surfaces with a straightedge and strike off.
 - 5. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
 - 6. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.
 - 7. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.
 - a. Compact subbase and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.
 - 8. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.
 - 9. Cold-Weather Placement: Comply with ACI 306.1. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 10. Hot-Weather Placement: Comply with ACI 301 when hot-weather conditions exist:

3.7 FLOAT FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water 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.
- C. Penetrating Liquid Slab Treatment: Prepare, apply, and finish penetrating liquid slab treatment according to manufacturer's written instructions.
1. Remove curing compounds, sealers, oil, dirt, laitance, and other contaminants and complete surface repairs.
 2. Do not apply to concrete that is less than seven days old.
 3. Apply liquid until surface is saturated, scrubbing into surface until a gel forms; rewet; and repeat brooming or scrubbing. Rinse with water; remove excess material until surface is dry. Apply a second coat in a similar manner if surface is rough or porous.

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, or a combination of these.

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-foot- long, unleveled straightedge not to exceed 1/2 inch.
 4. Joint Spacing: 3 inches.
 5. Contraction Joint Depth: Plus 1/4 inch, no minus.
 6. Joint Width: Plus 1/8 inch, no minus.

3.10 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.

- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
1. Testing Frequency: Obtain at least 1 composite sample for each 100 cu. yd. or fraction thereof of each concrete mix placed each day.
 - a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
 2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
 3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
 4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
 5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
 6. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
 - a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.
- C. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
- D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.
- F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.
- G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.
- H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.11 REPAIRS AND PROTECTION

- A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section.
- B. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement.
- 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 32 1313

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SECTION 32 1373 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold-applied joint sealants.

B. Related Sections:

1. Section 07 9200 "Joint Sealants" for sealing nontraffic and traffic joints in locations not specified in this Section.
2. Section 32 1313 "Concrete Paving" for constructing joints in concrete pavement.

1.2 ACTION SUBMITTALS

- A. Product Data: For each joint-sealant product indicated.

1.3 QUALITY ASSURANCE

- A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

1.4 PROJECT CONDITIONS

- A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.
2. When joint substrates are wet.
3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.

2.2 COLD-APPLIED JOINT SEALANTS

- A. Single-Component, Self-Leveling, Silicone Joint Sealant for Concrete: ASTM D 5893, Type SL.

1. Products: Subject to compliance with requirements, provide one of the following:
2. :
 - a. Crafcro Inc., an ERGON company; RoadSaver Silicone SL.
 - b. Dow Corning Corporation; 890-SL.
 - c. Pecora Corporation; 300 SL.

2.3 JOINT-SEALANT BACKER MATERIALS

- A. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.4 PRIMERS

- A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.
- B. Cleaning of Joints: Clean out joints immediately before installing joint sealants.
- C. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
- D. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- E. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 1. Do not leave gaps between ends of joint-sealant backings.
 2. Do not stretch, twist, puncture, or tear joint-sealant backings.
 3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

- F. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place joint sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses in each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- G. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.
- H. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

END OF SECTION 32 1373

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SECTION 32 1723 - PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes painted markings applied to asphalt pavement.
- B. Playground game markings including basketball
- C. Related Requirements:
 - 1. Section 09 9113 "Exterior Painting" for painting exterior concrete surfaces other than pavement.
 - 2. Section 09 9123 "Interior Painting" for painting interior concrete surfaces other than pavement.

1.2 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

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

1.4 FIELD CONDITIONS

- A. Environmental Limitations: 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 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Benjamin Moore Tru-flex Textured Colored Finish Coat TRC-28x or comparable product by one of the following:
- B. PPG Industries.
- C. Pratt & Lambert.
- D. Sherwin-Williams Company (The).

2.2 PAVEMENT-MARKING PAINT

- A. Pavement-Marking Paint: exterior marking paint. Color to be selected from manufacturers standard colors.

PART 3 - EXECUTION

3.1 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 a minimum of 30 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.
 - 1. Apply graphic symbols and lettering with paint-resistant, die-cut stencils. Apply paint so that it cannot run beneath the stencil.

END OF SECTION 32 1723

SECTION 32 1816.13 - PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Unitary synthetic poured rubber seamless surface.
 - 2. Organic loose-fill surface.
- B. Related Sections:
 - 1. Section 31 2000 "Earth Moving" for filling and grading

1.2 DEFINITIONS

- A. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."
- B. SBR: Styrene-butadiene rubber.
- C. CPSC; U.S. Consumer Product Safety Commission

1.3 PERFORMANCE REQUIREMENTS

- A. Impact Attenuation: According to ASTM F 1292.
- B. Accessibility of Surface Systems: According to ASTM F 1951.
- C. Minimum Characteristics for Organic Loose-Fill Surfaces: According to ASTM F 2075.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For each playground surface system, include materials, plans, cross sections, drainage, installation, penetration details, and edge termination including border edge tiles. Include patterns made by varying colors of surfacing.
- C. Samples for Initial Selection: For each item and accessory that requires color selection.
- D. Samples for Verification: For each type of playground surface system indicated.
 - 1. Minimum 6-by-6-inch Sample of synthetic rubber seamless surface.
 - 2. 6-inch long by full-size cross section of border edging.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material certificates.
- C. Material test reports.
- D. Product certificates.
- E. Product test reports.
- F. Field quality-control reports.
- G. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance data.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
- B. Source Limitations: Obtain playground surface system materials, including primers and binders, from single source from single manufacturer.
- C. Standards and Guidelines: Comply with CPSC No. 325, "Handbook for Public Playground Safety"; ASTM F 1292; and ASTM F 1487.

1.8 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Basis-of-Design Product: The design for each product is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 UNITARY SYNTHETIC SEAMLESS SURFACE

- A. Seamless Surface: Dual-density, poured-in-place system with wearing course over cushion course. Provide manufacturer's standard thickness for each layer as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.

1. Available Products:
 - a. GameTime, ; GT Impax. Poured in Place Surfacing or approved equal.
 - b.
2. Wearing Course: EPDM rubber particles and polyurethane.
3. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
4. Critical Height: 8 feet.
5. Overall Thickness: Not less than as required for critical height indicated.
6. Color: Two colors from manufactures standard colors to be selected by architect.

2.3 ORGANIC LOOSE-FILL SURFACE

- A. Engineered Wood Fibers: Random-sized wood fibers, in manufacturer's standard fiber size, approximately 10 times longer than wide; containing no bark, leaves, twigs, or foreign or toxic materials according to ASTM F 2075; graded according to manufacturer's standard specification for material consistency for playground surfaces and for accessibility according to ASTM F 1951.

1. Basis-of-Design Product: Brink Wood Products, Byron Center, Michigan or a comparable product of one of the following:
 - a.
2. Available Products:
 - a. Fibar, Inc.; Fibar System.
 - b. GameTime; GT Impax Fiber.
 - c.
3. Critical Height: 10 feet.
4. Uncompressed Material Depth: Not less than as required for critical height indicated.

2.4 LOOSE-FILL ACCESSORIES

- A. Edgings: Anchored-in-place, weather-resistant containment barrier designed to minimize sharp edges, protrusions, and tripping hazards; formed by interconnected, modular units.
 1. Polyethylene Units: UV-light-stabilized, 100 percent recycled polyethylene, not less than 1/4-inch wall thickness; made into smooth-surfaced straight units with radiused exposed edges and integral, molded-in color; in manufacturer's standard sizes.
 - a. Color: As selected from manufacturer's full range.

2. Anchor Stakes: Manufacturer's standard, of corrosion-resistant-coated metal or noncorrodible material, designed to be nonprotruding when installed, for connecting units and securing in-place.
- B. Stabilizing Mats: Manufacturer's standard, water-permeable PVC or rubber mats tested for impact attenuation according to ASTM F 1292, and rated for use in the following locations, with anchoring system designed to anchor mat securely to subgrade through engineered wood:
 1. Location: At excessive wear areas and as follows:
 - a. On top of loose-fill surface.
 - b. Under eachswing seat.
 2. Size: 40 by 40 inches.
 3. Color: As selected from manufacturer's full range.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Hard-Surface Substrates: Verify that substrates are satisfactory for unitary playground surface system installation and that substrate surfaces are dry, cured, and uniformly sloped to drain within recommended tolerances according to playground surface system manufacturer's written requirements for cross-section profile.
 1. Repair unsatisfactory surfaces and fill holes and depressions.
 2. Mechanically scarify or otherwise prepare concrete substrates to achieve recommended degree of roughness.
- B. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.
- C. Seamless Surface: Mix and apply components of playground surface system according to manufacturer's written instructions to produce a uniform, monolithic wearing surface and impact-attenuating system of total thickness indicated.
 1. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
 2. Poured Cushion Course: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
 3. Intercoat Primer: Over cured cushion course, apply primer at manufacturer's standard spreading rate.
 4. Wearing Course: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with no cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
 - a. Where graphics are indicated, place adjacent colored material as soon as placed colored material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.

- D. Loose Fill: Place playground surface system materials including manufacturer's standard amount of excess material for compacting mechanically to required depths after Installation of playground equipment support posts and foundations.
- E. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing and compacting of loose fill.
- F. Compacting and Grading: Uniformly compact and grade loose fill according to manufacturer's written instructions to an even surface free from irregular surface changes as indicated. Hand rake to a smooth finished surface and to required elevations.
- G. Finish Grading: Hand rake to a smooth finished surface and to required elevations.

3.2 FIELD QUALITY CONTROL

- A. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.
- B. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with requirements.

END OF SECTION 32 1816.13

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SECTION 32 3113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Chain-link fences.
2. Manual swing gates.

B. Related Sections:

1. Section 03 3000 "Cast-in-Place Concrete" for cast-in-place concrete post footings.
2. Section 03 3000 "Cast-in-Place Concrete"

C. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product indicated

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of chain-link fence, and gate, from manufacturer.

B. Sample of special warranty.

1.4 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which 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, 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 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. Comply with CLFMI Product Manual and with requirements indicated below:
1. Fabric Height: As indicated on Drawings.
 2. Steel Wire Fabric: Wire with a diameter of 0.192 inch.
 - a. Mesh Size: 2 inches or 1 1/4" as indicated on plans
 - b. Aluminum-Coated Fabric: ASTM A 491, Type I, 0.40 oz./sq. ft..Retain first subparagraph below for polymer coating over metallic-coated steel wire fabric.
 - c. Polymer-Coated Fabric: ASTM F 668, over aluminum-coated steel wire.
 - 1) Color: Black
 - d. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
 3. Aluminum Wire Fabric: ASTM F 1183, with mill finish, and wire diameter of 0.192 inch.
 - a. Mesh Size: 2 inches.
 4. Selvage: Knuckled at both selvages.

2.2 FENCE FRAMING

- A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 or ASTM F 1083 based on the following:
1. Fence Height: As indicated on plans
 2. Industrial Strength: Material Group IC-L, round steel pipe, electric-resistance-welded pipe.
 - a. Line Post: 2.37 inches in diameter.
 - b. End, Corner and Pull Post: 2.875 inches.
 3. Horizontal Framework Members: top and bottom rails complying with ASTM F 1043.
 - a. Top and Bottom Rail: 1.66 inches in diameter.
 4. Brace Rails: Comply with ASTM F 1043.
 5. Metallic Coating for Steel Framing:
 - a. Coatings: Any coating above.
 6. Polymer coating over metallic coating.
 - a. Color: Black

2.3 TENSION WIRE

- A. Metallic-Coated Steel Wire: 0.177-inch- diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:
1. Type I, aluminum coated (aluminized).

- B. Polymer-Coated Steel Wire: 0.148-inch- diameter, tension wire complying with ASTM F 1664, Class 2a over-coated steel wire.

- 1. Color: Black

2.4 SWING GATES

- A. General: Comply with ASTM F 900 for gate posts and double swing gate types.

- 1. Gate Leaf Width: As indicated.
 - 2. Gate Fabric Height: As indicated.

- B. Pipe and Tubing:

- 1. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; manufacturer's standard protective coating and finish.
 - 2. Gate Posts: Round tubular steel.
 - 3. Gate Frames and Bracing: Round tubular steel.

- A. Polymer-Coated Steel Wire: 0.148-inch- diameter, tension wire complying with ASTM F 1664, Class 2a over-coated steel wire.

- 1. Color: Black

- B. Frame Corner Construction: Welded.

- C. Hardware:

- 1. Hinges: 360-degree inward and outward swing.
 - 2. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.

2.5 FITTINGS

- A. General: Comply with ASTM F 626.

- B. Post Caps: Provide for each post.

- 1. Provide line post caps with loop to receive t top rail.

- C. Rail and Brace Ends: For each gate, corner, pull, and end post.

- D. Rail Fittings: Provide the following:

- 1. Rail Clamps: Line and corner boulevard clamps for connecting bottom rails in the fence line-to-line posts.

- E. Tension and Brace Bands: Aluminum Alloy 6063.

- F. Tension Bars: Aluminum, 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: Mill-finished aluminum rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
 - 1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
 - a. Aluminum: ASTM B 211; Alloy 1350-H19; 0.192-inch- diameter, mill-finished wire.
- I. Finish:
 - 1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. zinc.
 - a. Polymer coating over metallic coating.
 - 2. Aluminum: Mill finish.

2.6 GROUT AND ANCHORING CEMENT

- A. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.

2.7 FENCE GROUNDING

- A. Comply with requirements in Section 26 0526 "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 INSTALLATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
 - 1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.
 - 2. Proceed with installation only after unsatisfactory conditions have been corrected.

- B. 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.
- C. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.
- D. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- E. 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: Top below grade to allow covering with surface material when located in concrete pavement areas.
- F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of as indicated on Drawings.
- G. Line Posts: Space line posts uniformly at 10 feet o.c.
- H. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
- I. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Provide horizontal tension wire at the following locations:
- J. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- K. Bottom Rails: Install and secure to posts with fittings.
- L. Chain-Link Fabric: Apply fabric to inside of enclosing framework. Leave 1 inch between finish grade or surface and bottom selvage unless otherwise indicated.
- M. 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.
- N. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
 - 1. Maximum Spacing: Tie fabric to line posts at 12 inches o.c. and to braces at 24 inches o.c.
- O. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side.

- P. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.
- Q. 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.
- R. Grounding and Bonding:
 - 1. Fence Grounding: Install at maximum intervals of 1500 feet except as follows:
 - a. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet.
 - 1) Gates and Other Fence Openings: Ground fence on each side of opening.
 - a) Bond metal gates to gate posts.

END OF SECTION 32 3113

SECTION 32 8400 - PLANTING IRRIGATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Piping.
2. Encasement for piping.
3. Manual valves.
4. Automatic control valves.
5. Transition fittings.
6. Miscellaneous piping specialties.
7. Sprinklers.
8. Quick couplers.
9. Drip irrigation specialties.
10. Controllers.
11. Boxes for automatic control valves.

1.2 PERFORMANCE REQUIREMENTS

- A. Irrigation zone control shall be automatic operation with controller and automatic control valves.
- B. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.
- C. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
1. Irrigation Main Piping: 160 PSI.
 2. Circuit Piping: 160 PSI for PVC pipe and 100 PSI for polyethylene pipe.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Product Data sheets must be marked or highlighted to indicate specific model(s) of equipment/material intended to be installed. Submittals will be rejected if this instruction is not followed.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Zoning Chart: Show each irrigation zone and its control valve.

- C. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and maintenance data.

1.6 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers that include a certified irrigation contractor qualified by The Irrigation Association is preferred.
- 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.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. 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.
- B. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.8 PROJECT CONDITIONS

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

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. PE Pipe with Controlled OD: ASTM F 771, PE 3408 compound, SDR 11.
 - 1. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
 - 2. PE Socket-Type Fittings: ASTM D 2683.

- C. PVC Pipe, Pressure Rated: ASTM D 2241, PVC 1120 compound, [**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. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
- B. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.

2.3 AUTOMATIC CONTROL VALVES

- A. Plastic, Automatic Control Valves:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings.
 - 2. 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 Spray Sprinklers:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings.
 - 2. Capacities and Characteristics:
 - a. Flow: .05 gpm to 4.58 gpm (standard MPR nozzles).
 - b. Pop-up Height: 4" and 12".
 - c. Arc: Fixed (standard MPR nozzles) and adjustable patterns.
 - d. Radius: 5 feet to 15 feet (standard MPR nozzles).
 - e. Inlet: 1/2".

2.5 QUICK COUPLERS

- A. Description: Factory-fabricated, bronze or brass, one-piece body. Include coupler water-seal valve; weighted stainless steel cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

2.6 CONTROLLERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings.
- B. Description:
 - 1. Controller Stations for Automatic Control Valves: Each station is variable from approximately one minute to 10 hours. Include switch for manual or automatic operation of each station.
 - 2. Interior Control Enclosures: Weather resistant, with locking cover and two matching keys.
 - a. Body Material: Enameled-steel sheet metal or molded plastic.
 - b. Mounting: Surface type for wall.
 - 3. Control Transformer: 24-V secondary, with primary fuse.
 - 4. Timing Device: Adjustable, 24-hour, 7-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. Non-volatile memory: Retains programmed information in the event of a power outage.
 - c. Surge Protection: 2.0A slow-blow fuse.
 - 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.

2.7 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. Manufacturer shall be Highline Products or NDS.
 - a. Size: Minimum of a 10" valve box and cover shall be used for all automatic valves 1-1/2" and smaller and for all manual gate valves and quick coupling valves. Lids shall be green for automatic valves, black for manual gate valves and quick coupling valves. Side walls to extend at least 2 inches below the bottom of the valve body; for deep mainline appropriate extensions and/or corrugated plastic tile shall be used to reach depth of valves. Valve boxes shall not bear directly on pipe.
 - b. Shape: 6" and 10" Round.
 - c. Material: Rigid plastic material composed of fibrous components chemically inert and unaffected by moisture, corrosion and temperature changes.

1) Lettering: "IRRIGATION".

- 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 31 2000 "Earth Moving."
- B. Provide minimum cover over top of underground piping according to the following:

PVC	3/4" and 1"	Min.	12" of cover
PVC	1-1/4" to 2"	Min.	16" of cover
PVC	2-1/2" to 4"	Min.	20" of cover
PVC	6" to 8"	Min.	24" of cover
Poly Lateral	All	Min.	10" of cover
Techline	All	Min.	Depth per manufacturer
Sleeving	All sizes	Min.	12" to 18" of cover

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 free of sags and bends.
- C. Install groups of pipes parallel to each other, spaced to permit valve servicing.
- D. Install fittings for changes in direction and branch connections.
- E. Lay piping on solid subbase, uniformly sloped without humps or depressions.
- F. 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.
- G. Install piping in sleeves under parking lots, roadways, and sidewalks.
- H. Install sleeves made of PVC pipe (material as stated on plan) and socket fittings, and solvent-cemented joints.

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. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.
- F. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.
- G. 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.
- H. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.
- I. 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 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.

3.5 AUTOMATIC IRRIGATION-CONTROL SYSTEM INSTALLATION

- A. Equipment Mounting: Install interior controllers on wall.
 - 1. Place and secure anchorage devices. Use 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.

- B. 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.

3.6 IDENTIFICATION

- A. Identify system components. Comply with requirements for identification specified in Section 22 0553 "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.

3.7 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.

3.8 STARTUP SERVICE

- 1. Complete installation and startup checks according to manufacturer's written instructions.
- 2. Verify that controllers are installed and connected according to the Contract Documents.
- 3. Verify that electrical wiring installation complies with manufacturer's submittal.

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.

3.10 Warranty

- A. For a period of one year from date of final acceptance of the work performed under this contract, the Contractor shall promptly furnish, without cost to the Owner, any and all parts and labor which prove defective in material or workmanship.
- B. A full 5-year manufacturer's warranty on all sprinkler heads, electric valves and controllers shall be provided by the Irrigation Contractor. Any of these parts proven to be defective within the 5-year warranty period shall be replaced with no cost to the owner for parts. After the 1-year labor warranty has expired, the owner shall be responsible for the labor to replace defective sprinkler heads, electric valves and controllers.
- C. In the fall following the installation, the Contractor shall winterize the system and the following spring shall put the system back into operation. Winter damage due to improper winterization is the responsibility of the Contractor.
- D. It shall be the contractor's responsibility to insure and guarantee complete coverage of the areas shown on the drawings to be irrigated. He shall also guarantee the satisfactory operations of the entire system and the workmanship and restoration of the area. Adjustment of the sprinkler heads and automatic equipment will be done by the contractor, upon completion of installation, to provide optimum performance.

END OF SECTION 32 8400

SECTION 32 9200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding; Lawn, Non-Maintained and Wet Area seed mixes.
2. Topsoil Testing and Improving Soils per recommendations
3. Hydromulching.
4. Erosion-control material(s).

B. Related Sections:

1. Section 31 1000 "Site Clearing" for topsoil stripping and stockpiling.
2. Section 31 2000 "Earth Moving" for excavation, filling and backfilling, and rough grading.

1.2 DEFINITIONS

- A. Finish Grade: Elevation of finished surface of planting soil.
- B. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- C. 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.
- D. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- E. Topsoil: Topsoil proposed for use to be processed and shall meet tested criteria results specified and conform to adjustments as recommended by the soil testing laboratory.
- F. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- G. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- H. Surface Soil: Whatever soil is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.3 INFORMATIONAL SUBMITTALS

- A. Soils analysis report with a list of soil amendments that will be added to soil to meet laboratory's recommendations.
- B. Source of topsoil
- C. Procedure to amend topsoil.
- D. Seed Mix.
- E. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for. Include identification of source and name and telephone number of supplier.
- F. Qualification Data: For qualified landscape Installer.
- G. QUALITY ASSURANCE
- H. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.
- I. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
 - 1. Pesticide Applicator: State licensed, commercial.
- J. Soil-Testing Laboratory Qualifications: Laboratory recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.
- K. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory.
- L.
 - 1. Report suitability of tested soil for turf growth.
 - a. State recommendations for nitrogen, phosphorus, potassium, magnesium and calcium nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals; if present, provide additional recommendations for corrective action.
- M. Preinstallation Conference: Conduct conference at Project site.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

1.5 MAINTENANCE SERVICE

- A. Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
 - 1. Seeded Turf: 60 days from date of planting completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Lawn Seed Species: State-certified seed of grass species as follows:
 - 1. Sun and Partial Shade: Proportioned by weight as follows:
 - a. 50 percent Kentucky, 2 varieties
 - b. 25 percent Creeping Red Fescue
 - c. 25 percent Turf Type Perennial Rye
- C. Non-Mowed Natural Seed Mix; Low Maintenance Meadow Mix by Rhino Seed.
 - 50% Var. Chewing Fescue
 - 30% Var. Hard Fescue
 - 20% Sheep Fescue
- A. Wet Area Seed Mix: Butterfly Garden Mix by Michigan Wildflower Farm, Portland, Michigan

2.2 FERTILIZERS

- A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 10 percent nitrogen, 20 percent phosphorous, and 10 percent potassium, by weight.

2. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

2.3 TOPSOILS

- A. On site stockpiled clean debris free topsoil with no subsoils intermixed. Topsoil to be tested per this spec. Verify suitability of soil to produce viable planting soil. Soil to be fertile, friable and representative of local production soil, capable of sustaining vigorous plant growth and screened free of roots, plants, sod, stones, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Remove all stones 2 inch and larger. On average, no more than 3 stones, 1/4 inch and larger should be visible with in a 6 inch by 6 inch area.
- B. ASTM D 5268 topsoil from the top surface horizon layer.
- C. Topsoil shall have a pH range of 5.5 to 7.5, adjusted to not more than 7.0 by additives as required by soils test.
- D. Topsoil shall be not less than 2% and not greater than 5% native organic matter, not compost material, as determined by a loss by ignition test at 360 degrees C.
- E. Topsoil to have a soil textural classification of Sandy Loam.
- F. Topsoil clay content as determined by Bouyoucous Hydrometer Test shall range between 5% and 20%
- G. Topsoil sand content shall be not less than 40% and not greater than 80%, as determined by a mechanical analysis.

2.4 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Hydromulch after seeding

2.5 PESTICIDES

- A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.6 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: As identifies on civil's plans. Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long. Or as indicated on soil erosion plan.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways as indicated on soil erosion plan.

3.2 TURF AREA PREPARATION

- A. Test Topsoil at 12 random spaced areas across the project site per soil testing agency
- B. Amend topsoil as recommended by soil testing agency
- C. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Spread topsoil to a depth of 6 inches but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if topsoil or subgrade is frozen, muddy, or excessively wet.
- D. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of at least 4 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.
 - 3. Remove stones larger than ½ inch in any dimension and sticks, roots, trash, and other extraneous matter.
 - 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- E. Hand Rake: Hand rake topsoil areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
- F. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- G. Before planting, obtain Architect's acceptance of hand raking; restore planting areas if eroded or otherwise disturbed after finish grading.

3.3 PREPARATION FOR EROSION-CONTROL MATERIALS

- A. Prepare area as specified in "Turf Area Preparation" Article.
- B. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.

- C. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.4 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow Lawn and Non-maintained seed at a total rate of 5 to 8 lb/1000 sq. ft..
- C. Sow Wet Area Seed Mix at 15 pounds per acre.
- D. Hand rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- E. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets installed and stapled according to manufacturer's written instructions.
- F. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.
- G. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre to form a continuous blanket 1-1/2 inches in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.
- H. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of 3/16 inch, and roll surface smooth.

3.5 TURF RENOVATION

- A. Renovate existing turf.
- B. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
 - 1. Reestablish turf where settlement or washouts occur or where minor regrading is required.
 - 2. Install new planting soil as required.
- C. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
- D. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
- E. Mow, dethatch, core aerate, and rake existing turf.
- F. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.

- G. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off Owner's property.
- H. Till stripped, bare, and compacted areas thoroughly to a soil depth of 6 inches.
- I. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top 4 inches of existing soil. Install new planting soil to fill low spots and meet finish grades.
- J. Apply seed and protect with straw mulch as required for new turf.
- K. Water newly planted areas and keep moist until new turf is established.

3.6 TURF WATERING AND MAINTENANCE

- A. Water 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. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of 4 inches.
 - 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 2. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- C. Mow Lawn turf as soon as top growth is tall enough to cut. Repeat mowing to maintain height appropriate for species without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings.
- D. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

3.7 SATISFACTORY TURF

- A. Turf installations shall meet the following criteria as determined by Architect:
 - 1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. 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.
- C. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.

1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.

3.8 PESTICIDE APPLICATION

- A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.
- B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

END OF SECTION 32 9200

SECTION 32 9300 - PLANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plants.
2. Planting soils.
3. Tree stabilization.
4. Landscape edgings.

B. Related Sections:

1. Section 31 2000 "Earth Moving" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
2. Section 32 9200 "Turf and Grasses" for turf (lawn) and meadow planting, hydroseeding, and erosion-control materials.

1.2 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- C. Finish Grade: Elevation of finished surface of planting soil.
- D. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- E. 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.
- F. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
- G. Topsoil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- H. 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.
- I. 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.

- J. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- K. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.3 SUBMITTALS

- A. Qualification Data: For landscape Installer.
- B. Product certificates.
- C. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of plants during a calendar year.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful establishment of plants.
 - 1. Experience: 8 years' experience in landscape installation in addition to requirements in Section 01 4000 "Quality Requirements."
 - 2. Pesticide Applicator: State licensed, commercial.
- B. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
 - 1. Selection of plants purchased under allowances will be made by Architect, who will tag plants at their place of growth before they are prepared for transplanting.
- C. Preinstallation Conference: Conduct conference at Project site.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
- B. 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.
- C. Handle planting stock by root ball.
- D. 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.

1.6 PROJECT CONDITIONS

- A. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions and warranty requirements.
- B. Coordination with Turf Areas (Lawns): Plant trees, shrubs, and other plants after finish grades are established and before planting turf areas unless otherwise indicated.
 - 1. When planting trees, shrubs, and other plants after planting turf areas, protect turf areas, and promptly repair damage caused by planting operations.

1.7 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, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling or blowing over.
 - 2. Warranty Periods from Date of Planting Completion:
 - a. Trees, Shrubs, Plants, and Ornamental Grasses: 12 month

1.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.
 - 1. Maintenance Period for Trees and Plants: 12 months from date of planting completion.
- B. Continuing Maintenance Proposal: From Installer to Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

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 Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

- B. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- C. If formal arrangements or consecutive order of plants is shown on Drawings, select stock for uniform height and spread, and number the labels to assure symmetry in planting.

2.2 INORGANIC SOIL AMENDMENTS

- A. Sand: Clean, washed, natural or manufactured, and free of toxic materials.

2.3 ORGANIC SOIL AMENDMENTS

- A. Compost,, finely divided or granular texture, with a pH range of 3.4 to 4.8.

2.4 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: 21-gram tablets.
 - 2. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.

2.5 TOILS

- A. Topsoil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 2 percent organic material content. Imported soil.. Verify suitability of soil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix soil with the following soil amendments in the following quantities to produce planting soil:
 - 1. Planting Soil; one third each; topsoil, sand and compost

2.6 MULCHES

- A. Organic Mulch: Shredded hardwood bark mulch.
- B. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings.
- C. Mineral Mulch: Crushed stone or gravel.
 - 1. Size Range: 1-1/2 inches maximum, 3/4 inch minimum.
 - 2. Color: Readily available natural gravel color range.

2.7 WEED-CONTROL BARRIERS

- A. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd.. At mineral mulch only.

2.8 PESTICIDES

- A. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

2.9 TREE STABILIZATION MATERIALS

- A. Stakes and Guys:
 - 1. Upright and Guy Stakes: hardwood 2-by-2-inch nominal by length required to secure tree.
 - 2. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes.
 - 3. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch in diameter.
 - 4. Flags: Standard surveyor's plastic flagging tape, white, 6 inches long.
 - 5. Proprietary Staking-and-Guying Devices: Proprietary stake and adjustable tie systems to secure each new planting by plant stem; sized as indicated and per manufacturer's written recommendations.

2.10 LANDSCAPE EDGINGS

- A. Aluminum Edging: Standard-profile extruded-aluminum edging, ASTM B 221, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Insert manufacturer's name; product name or designation or comparable product by one of the following:
 - a. Curv-Rite, Inc.
 - b. Permaloc Corporation.
 - 2. Edging Size: 3/16 inch wide by 5 1/2 inches deep.
 - 3. Stakes: Aluminum, ASTM B 221, Alloy 6061-T6, approximately 1-1/2 inches wide by 12 inches long.
 - 4. Finish: Black anodized.

PART 3 - EXECUTION

3.1 PLANTING AREA ESTABLISHMENT

- A. Loosen subgrade of planting areas to a minimum depth of . Remove stones larger than 2 inches in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.

1. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 2. Spread planting soil to a depth of 8 inches but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
- B. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.

3.2 EXCAVATION FOR TREES AND SHRUBS

- A. Planting Pits and Trenches: Excavate circular planting pits with vertical sides. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
1. Excavate approximately three times as wide as ball diameter.
 2. Excavate at least 12 inches wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
 3. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
- B. Subsoil and topsoil removed from excavations may not be used as planting soil.

3.3 TREE, SHRUB, AND VINE PLANTING

- A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1.
- B. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
- C. Set stock plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
1. Use planting soil for backfill.
 2. Balled and Burlapped: 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. Balled and Potted Container-Grown: Carefully remove root ball from container without damaging root ball or plant.
 4. 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.
 5. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about 1 inch from root tips; do not place tablets in bottom of the hole.
 6. Continue backfilling process. Water again after placing and tamping final layer of soil.

- D. 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 according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.

3.5 PLANTING AREA MULCHING

- A. Install weed-control barriers at mineral mulches before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of 6 inches and secure seams with galvanized pins.
- B. Mulch backfilled surfaces of planting areas and other areas indicated.
 - 1. Trees and Tree-like Shrubs in Turf Areas: Apply organic mulch ring of 2-inch average thickness, with 12-inch radius around trunks or stems.

3.6 EDGING INSTALLATION

- A. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately 36 inches apart, driven below top elevation of edging.

3.7 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. Spray or treat as required to keep trees and shrubs free of insects and disease.
- B. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
- C. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use practices to minimize the use of pesticides and reduce hazards.
- D. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

**PROJECT NO. 21237.20
HAVERHILL ELEMENTARY SCHOOL BID PACKAGE 6 - CONSTRUCTION
PORTAGE PUBLIC SCHOOLS**

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- 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.

END OF SECTION 32 9300

SECTION 33 4200 – STORMWATER CONVEYANCE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ductile-iron culvert pipe and fittings.
2. PE pipe and fittings.
3. PVC pipe and fittings.
4. Concrete pipe and fittings.
5. Non-pressure transition couplings.
6. Expansion joints.
7. Cleanouts.
8. Encasement for piping.
9. Manholes.
10. Polymer-concrete, channel drainage systems.
11. Catch basins.
12. Stormwater inlets.
13. Stormwater detention structures.
14. Pipe outlets.

1.2 ACTION SUBMITTALS

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

B. Sustainable Design Submittals:

C. 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.
3. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

1.3 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
- B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1-inch equals 50 feet and vertical scale of not less than 1 inch equals 5 feet. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.
- C. Product Certificates: For each type of cast-iron soil pipe and fitting.

- D. Field quality-control reports.

1.4 PROJECT CONDITIONS

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

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Regulatory Requirements:
 - 1. Comply with City of Portage standards for sanitary sewer piping, including materials, installation, and testing for all improvements in the proposed public right-of-way.

PART 2 - PRODUCTS

2.1 LOCAL REQUIREMENTS

- A. All materials in the proposed public right-of-way shall comply with City of Portage standards for storm sewer construction, current edition.

2.2 PIPING MATERIALS

- A. Refer to drawings for types of pipe and the corresponding fittings and joining materials required throughout the project. Any approved material listed below can be utilized if not specified on the drawings.
 - 1. Note: All storm utility piping in the public road right-of-way shall be concrete pipe or PE Sanitite pipe as specified below.
 - 2. All other storm piping may be any of the materials listed.

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

- A. Pipe and Fittings:
 - 1. Marked with CISPI collective trademark and NSF certification mark.
 - 2. Class: ASTM A74, Service class.
- B. Gaskets: ASTM C564, rubber.

- C. Caulking Materials: ASTM B29, pure lead and oakum or hemp fiber.

2.4 CORRUGATED-PE PIPE AND FITTINGS

- A. Corrugated-PE Drainage Pipe and Fittings NPS 3 to NPS 10: AASHTO M 252, Type S, with smooth waterway for coupling joints.
- B. Corrugated-PE Pipe and Fittings NPS 12 to NPS 60: AASHTO M 294, Type S, with smooth waterway for coupling joints.
- C. Corrugated-PE Silttight Couplings: PE sleeve with ASTM D1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
- D. Corrugated-PE Soiltight Couplings: AASHTO M 294, corrugated, matching pipe and fittings.

2.5 CONCRETE PIPE AND FITTINGS

- A. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 , Class III, with bell-and-spigot ends, and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets.
- B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76, Class III, with bell-and-spigot [or] [groove and tongue] ends, and gasketed joints with ASTM C 443(ASTM C 443M), rubber gaskets.

2.6 NONPRESSURE-TYPE PIPE 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 corrosion-resistant-metal tension band and tightening mechanism on each end.
- B. Sleeve Materials:
 - 1. For Concrete Pipes: ASTM C443, rubber.
 - 2. For Cast-Iron Soil Pipes: ASTM C564, rubber.
 - 3. For Fiberglass Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
 - 4. For Plastic Pipes: ASTM F477, elastomeric seal or ASTM D5926, PVC.
 - 5. For Dissimilar Pipes: ASTM D5926, PVC or other material compatible with pipe materials being joined.
- C. Unshielded, Flexible Couplings
 - 1. Description: Elastomeric sleeve with corrosion-resistant-metal tension band and tightening mechanism on each end.
- D. Shielded, Flexible Couplings:
 - 1. Description: ASTM C1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
- E. Ring-Type, Flexible Couplings:

1. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.7 CLEANOUTS

- A. Description: Cast-iron cleanout with threaded adjustable housing, flanged ferrule, brass cleanout plug, and round cast-iron heavy-duty, secured, scoriated cover. Wade Model 6000Z-75-179 or equivalent.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. MIFAB Manufacturing Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Wade Div.; Tyler Pipe.
 - e. Zurn Industries, Inc.; Zurn Specification Drainage Operation.
 2. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

2.8 MANHOLES

- A. Standard Precast Concrete Manholes: ASTM C 478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 1. Diameter: 48 inches minimum, unless otherwise indicated.
 2. Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
 3. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and having separate base slab or base section with integral floor.
 4. Riser Sections: 4-inch minimum thickness, and of length to provide depth indicated.
 5. Top Section: Eccentric-cone type unless flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 6. Joint Sealant: ASTM C 990, bitumen or butyl rubber.
 7. Resilient Pipe Connectors: ASTM C 923, cast or fitted into manhole walls, for each pipe connection.
 8. Steps: Individual FRP steps, or ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches.
 9. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
 10. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

2.9 LEACHING BASINS

- A. Standard Precast Concrete Manholes: ASTM C 478 , precast, reinforced concrete, of depth indicated, with provision for sealant joints.
1. Diameter: 72 inches minimum, unless otherwise indicated.
 2. Base Section: 10-inch minimum thickness for floor slab.
 3. Riser Sections: 7-inch minimum thickness, and of length to provide depth indicated with 3-inch (75 mm) diameter precast openings spaced 12-inch (25 mm) on center around the riser perimeter every 12-inch (25 mm) of depth from top to bottom for drainage.
 4. Top Section: Eccentric-cone type unless flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 5. Joint Sealant: ASTM C 990 , bitumen or butyl rubber.
 6. Steps: Individual FRP steps, or ASTM A 615/A 615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D 4101, PP, wide enough to allow worker to place both feet on 1 step and designed to prevent lateral slippage off of step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches .
 7. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
 8. Grade Rings: Reinforced-concrete rings, 6- to 9-inch total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

2.10 CONCRETE

- A. General: Cast-in-place concrete according to ACI 318, ACI 350, and the following:
1. Cement: ASTM C 150/C 150M, Type II.
 2. Fine Aggregate: ASTM C 33/ C 33M, sand.
 3. Coarse Aggregate: ASTM C 33/C 33M, crushed gravel.
 4. Water: Potable.
- B. Portland Cement Design Mix: 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio.
1. Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
 2. Reinforcing Bars: ASTM A615/A615M, Grade 60 (420 MPa) deformed steel.
- C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
 - a. Invert Slope: 1 percent through manhole.
 2. Benches: Concrete, sloped to drain into channel.
 - a. Slope: 4 percent.

- D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi minimum, with 0.58 maximum water-cementitious materials ratio.
 - 1. Reinforcement Fabric: ASTM A 185, steel, welded wire fabric, plain.
 - 2. Reinforcement Bars: ASTM A 615/A 615M, Grade 60, deformed steel.

2.11 CATCH BASINS

- A. Standard Precast Concrete Catch Basins: ASTM C478, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
 - 1. Base Section: 6-inch minimum thickness for floor slab and 4-inch minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
 - 2. Riser Sections: 4-inch minimum thickness, 48-inch diameter, and lengths to provide depth indicated.
 - 3. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
 - 4. Joint Sealant: ASTM C990, bitumen or butyl rubber.
 - 5. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
 - 6. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch total thickness, that match 24-inch- diameter frame and grate.
 - 7. Steps: [Individual FRP steps or FRP ladder] [Individual FRP steps; FRP ladder; or ASTM A615/A615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D4101, PP] [ASTM A615/A615M, deformed, 1/2-inch steel reinforcing rods encased in ASTM D4101, PP, 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 catch basin to finished grade is less than 60 inches.
 - 8. Pipe Connectors: ASTM C923, resilient, of size required, for each pipe connecting to base section.
- B. Frames and Grates: ASTM A536, Grade 60-40-18, ductile iron designed for A-16 (AASHTO HS20-44), structural loading. Include flat grate with small square or short-slotted drainage openings.
 - 1. Size and Type: See drawings.

2.12 STORMWATER INLETS

- A. Curb Inlets: Made with vertical curb opening, of materials and dimensions in accordance with City of Portage standards.
- B. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions in accordance with City of Portage standards. Include heavy-duty frames and grates.
- C. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions in accordance with City of Portage standards. Include heavy-duty frames and grates.
- D. Frames and Grates: Heavy duty, in accordance with City of Portage standards.

2.13 PIPE OUTLETS

- A. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.
- B. Riprap Basins: Broken, irregularly sized and shaped, graded stone in accordance with NSSGA's "Quarried Stone for Erosion and Sediment Control."
 - 1. Average Size: NSSGA No. R-3, screen opening 2 inches.
 - 2. Average Size: NSSGA No. R-4, screen opening 3 inches.
 - 3. Average Size: NSSGA No. R-5, screen opening 5 inches.

2.14 CATCH BASIN/DRY WELLS

- A. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size, graded stone.
- B. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton average weight armor stone, unless otherwise indicated.

PART 3 - EXECUTION

3.1 CITY SPECIFICATIONS

- A. All installation and workmanship shall comply with the City of Portage standards for storm sewer construction, current edition.

3.2 EARTHWORK

- A. Excavating, trenching, and backfilling are specified in Section 31 2000 "Earth Moving."

3.3 PIPING INSTALLATION

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take 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 in accordance with manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
- D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

- E. Install gravity-flow, nonpressure drainage piping according to the following:
 - 1. Install piping pitched down in direction of flow, at minimum slope of 1 percent, unless otherwise indicated.
 - 2. Install piping below frost line.
 - 3. Install PVC sewer piping in accordance with ASTM D2321 and ASTM F1668.
 - 4. Install nonreinforced-concrete sewer piping in accordance with ASTM C1479 and ACPA's "Concrete Pipe Installation Manual."
 - 5. Install reinforced-concrete sewer piping in accordance with ASTM C1479 and ACPA's "Concrete Pipe Installation Manual."
- F. Install corrosion-protection piping encasement over the following underground metal piping in accordance with ASTM A674 or AWWA C105/A21.5:
 - 1. Hub-and-spigot, cast-iron soil pipe and fittings.
 - 2. Hubless cast-iron soil pipe and fittings.
 - 3. Ductile-iron pipe and fittings.
 - 4. Expansion joints.
- G. Clear interior of piping and manholes of dirt and superfluous material as work progresses.

3.4 PIPE JOINT CONSTRUCTION

- A. Join gravity-flow, nonpressure drainage piping according to the following:
 - 1. Join corrugated-PE piping in accordance with ASTM D3212 for push-on joints.
 - 2. Join PVC corrugated sewer piping in accordance with ASTM D2321 for elastomeric-seal joints.
 - 3. Join reinforced-concrete sewer piping in accordance with ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
 - 4. Join dissimilar pipe materials with nonpressure-type flexible couplings.

3.5 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches deep. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in pavement with tops flush with pavement surface.

3.6 MANHOLE INSTALLATION

- A. General: Install manholes, complete with appurtenances and accessories indicated.
- B. Install precast concrete sections with sealants according to ASTM C 891.
- C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

- D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches above finished surface elsewhere, unless otherwise indicated.

3.7 CATCH BASIN INSTALLATION

- A. Construct catch basins to sizes and shapes indicated.
- B. Set frames and grates to elevations indicated.

3.8 STORMWATER INLET INSTALLATION

- A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
- B. Construct riprap of broken stone, as indicated.
- C. Install outlets that spill onto grade, anchored with concrete, where indicated.
- D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
- E. Construct energy dissipaters at outlets, as indicated.

3.9 CONCRETE PLACEMENT

- A. Place cast-in-place concrete in accordance with ACI 318.

3.10 CATCH BASIN/DRYWELL INSTALLATION

3.11 CLOSING ABANDONED STORM SYSTEM

- A. Abandoned Piping: Close open ends of abandoned underground piping that is indicated to remain in place. Provide sufficiently strong closures to withstand hydrostatic or earth pressure that may result after ends of abandoned utilities have been closed.
 - 1. Close open ends of concrete or masonry utilities with not less than 8 inch thick brick masonry bulkheads.
 - 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Wood plugs are not acceptable.
- B. Abandoned Structures: Remove structure and close open ends of the remaining piping or remove top of structure down to not less than 3 feet below final grade; fill structure with stone, rubble, gravel, or compacted dirt, to within 1 foot of top of structure remaining, and fill with concrete.

3.12 CONNECTIONS

- A. Connect nonpressure, gravity-flow drainage piping to building's storm building drains and downspouts according to the details on the drawings and as specified in Section 22 1413 "Facility Storm Drainage Piping."
- B. Make connections to existing piping and underground structures so that finished work will conform as nearly as practicable to the requirements specified for new work and with municipal storm system requirements.

3.13 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

- A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
 - 1. Close open ends of piping with at least 8 inch thick, brick masonry bulkheads.
 - 2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
- B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
 - 1. Remove manhole or structure and close open ends of remaining piping.
 - 2. Remove top of manhole or structure down to at least 36 inches below final grade. Fill to within 12 inches of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
- C. Backfill to grade in accordance with Section 31 2000 "Earth Moving."

3.14 IDENTIFICATION

- A. Materials and their installation are specified in Section 31 2000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
 - 1. Use detectable warning tape over ferrous piping.
 - 2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.15 FIELD QUALITY CONTROL

- A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
 - 1. Submit separate report for each system inspection.
 - 2. Defects requiring correction include the following:
 - a. Alignment: Less than full diameter of inside of pipe is visible between structures.
 - b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
 - c. Crushed, broken, cracked, or otherwise damaged piping.
 - d. Infiltration: Water leakage into piping.

- e. Exfiltration: Water leakage from or around piping.
- 3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.
- 4. Reinspect and repeat procedure until results are satisfactory.
- B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
 - 1. Do not enclose, cover, or put into service before inspection and approval.
 - 2. Perform mandrel testing for all PE storm piping more than 30 days after installed. Mandrel shall be 95% of pipe ID.

3.16 CLEANING

- A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION 33 4200

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SECTION 33 4600 - SUBDRAINAGE

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes subdrainage systems for foundations, pavements.
- B. Related Sections include the following:
 - 1. Division 07 waterproofing Sections for molded-sheet drainage panels.

1.2 SUBMITTALS

- A. Product Data: For each type of drainage panel indicated.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

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

2.3 PERFORATED-WALL PIPES AND FITTINGS

- A. Perforated PE Pipe and Fittings:
 - 1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
 - 2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
 - 3. Couplings: Manufacturer's standard, band type.
- B. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.

- C. Perforated Clay Pipe and Fittings: ASTM C 700, Standard- and Extra-Strength classes, unglazed, socket-and-spigot ends, for gasketed joints.
 - 1. Gaskets: ASTM C 425, rubber.
- D. Perforated Concrete Pipe and Fittings: ASTM C 444, Type 1, and applicable requirements in ASTM C 14, Class 2, socket-and-spigot ends for gasketed joints.
 - 1. Gaskets: ASTM C 443, rubber.

2.4 SPECIAL PIPE COUPLINGS

- A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.
 - 1. Unshielded Flexible Couplings: Elastomeric sleeve with[stainless-steel shear ring and] corrosion-resistant metal tension band and tightening mechanism on each end.
 - 2. Shielded Flexible Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant metal tension band and tightening mechanism on each end.

2.5 CLEANOUTS

- A. Cast-Iron Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing; and secured, scoriated, Medium-Duty Loading class, cast-iron cover. Include cast-iron ferrule and countersunk, brass cleanout plug.
- B. Copper-Alloy Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing with clamping device; and scoriated, Medium-Duty Loading class, copper-alloy cover. Include countersunk, brass cleanout plug.
- C. PVC Cleanouts: ASTM D 3034, PVC cleanout threaded plug and threaded pipe hub.

2.6 DRAINAGE CONDUITS

- A. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cusped, molded-plastic drainage core wrapped in geotextile filter fabric.
 - 1. [Available]Manufacturers:
 - a. American Wick Drain Corporation.
 - b. JDR Enterprises, Inc.
 - c. TC Mirafi.
 - 2. when tested according to ASTM D 4491.

2.7 SOIL MATERIALS

- A. Backfill, drainage course, impervious fill, and satisfactory soil materials are specified in Division 31 Section "Earth Moving."

2.8 ROOFING FELTS

- A. [ASTM D 226, Type I, asphalt] [or] [ASTM D 227, coal-tar]-saturated roofing felt.

2.9 GEOTEXTILE FILTER FABRICS

- A. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. when tested according to ASTM D 4491.
 - 1. Structure Type: [Nonwoven, needle-punched continuous filament] [or] [woven, monofilament or multifilament].
 - 2. Structure Type: Nonwoven, needle-punched continuous filament or woven, monofilament or multifilament.
 - 3. Style(s): [Flat] [and] [sock].
 - 4. Style(s): Flat and sock.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces and areas for suitable conditions where subdrainage systems are to be installed.
- B. If subdrainage is required for landscaping, locate and mark existing utilities, underground structures, and aboveground obstructions before beginning installation and avoid disruption and damage of services.

3.2 EARTHWORK

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

3.3 PIPING APPLICATIONS

- A. Underground Subdrainage Piping:
 - 1. Perforated PE pipe and fittings, couplings, and coupled joints.
 - 2. Perforated PVC sewer pipe and fittings for loose, bell-and-spigot joints.
 - 3. Perforated clay pipe and fittings, [Standard] [Extra]-Strength class; gaskets; and gasketed joints.
- B. Underslab Subdrainage Piping:
 - 1. Perforated PE pipe and fittings, couplings, and coupled joints.
 - 2. Perforated PVC sewer pipe and fittings and loose, bell-and-spigot joints.

3. Perforated clay pipe and fittings, Extra-Strength class; gaskets; and gasketed joints.
4. Perforated concrete pipe and fittings, gaskets, and gasketed joints.

C. Header Piping:

1. ABS pipe and fittings[, gaskets, and gasketed] [and solvent-cemented] joints.
2. Cast-iron soil pipe and fittings, [Extra-Heavy] [Service] class; gaskets; and gasketed joints.
3. PE drainage tubing and fittings, couplings, and coupled joints.
4. PVC sewer pipe and fittings, couplings, and coupled joints.

3.4 CLEANOUT APPLICATIONS

A. In Underground Subdrainage Piping:

1. At Grade in Earth: PVC cleanouts.
2. At Grade in Paved Areas: Cast-iron cleanouts.

B. In Underslab Subdrainage Piping:

1. In Equipment Rooms and Unfinished Areas: Cast-iron cleanouts.
2. In Finished Areas: Copper-alloy cleanouts.

3.5 FOUNDATION DRAINAGE INSTALLATION

- A. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches deep and 12 inches wide.
- B. Place impervious fill on subgrade adjacent to bottom of footing and compact to dimensions indicated, but not less than 6 inches wide after concrete footing forms have been removed.
- C. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- D. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches .
- E. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [adhesive] [or] [tape].
- F. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
- G. Install drainage piping as indicated in Part 3 "Piping Installation" Article for foundation subdrainage.
- H. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- I. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe to within 12 inches of finish grade.

- J. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and 6 inches above top of pipe and extend to cover minimum 6 inches of bottom of drainage panel.
- K. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- L. Place layer of [flat-style geotextile filter fabric] [roofing felt] over top of drainage course, overlapping edges at least 4 inches.
- M. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches .
- N. Install vertical drainage panels as follows:
 - 1. Coordinate placement with other drainage materials.
 - 2. Lay perforated drainage pipe at base of footing. Install as indicated in Part 3 "Piping Installation" Article. Do not install aggregate.
- O. . Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.

3.6 UNDERSLAB DRAINAGE INSTALLATION

- A. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least 6 inches between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches .
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [adhesive] [or] [tape].
- E. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
- F. Install drainage piping as indicated in Part 3 "Piping Installation" Article for underslab subdrainage.
- G. Add drainage course to width of at least 6 inches on both sides and to top of pipe to perform tests.
- H. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.
- I. Install horizontal drainage panels as follows:
 - 1. Coordinate placement with other drainage materials.
 - 2. Lay perforated drainage pipe at inside edge of footings.
 - 3. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.

4. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.

3.7 PLAZA DECK DRAINAGE INSTALLATION

- A. Horizontal Drainage Panel: Install between slab and floor cover. Place core on structural floor. Install panels to fit tightly around floor drains of building's storm drainage system. Provide stormwater access into floor drain.
 1. Install drainage piping as indicated in Part 3 "Piping Installation" Article for plaza deck subdrainage.
- B. See Division 32 Section "Unit Paving."

3.8 RETAINING-WALL DRAINAGE INSTALLATION

- A. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- B. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than 4 inches .
- C. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with [adhesive] [or] [tape].
- D. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
- E. Install drainage piping as indicated in Part 3 "Piping Installation" Article for retaining-wall subdrainage.
- F. Add drainage course to width of at least 6 inches on side away from wall and to top of pipe to perform tests.
- G. After satisfactory testing, cover drainage piping to width of at least 6 inches on side away from footing and above top of pipe to within 12 inches of finish grade.
- H. Place drainage course in layers not exceeding 3 inches in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.
- I. Place layer of [flat-style geotextile filter fabric] [roofing felt] over top of drainage course, overlapping edges at least 4 inches.
- J. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches .
- K. Install vertical drainage panels as follows:
 1. Coordinate placement with other drainage materials.
 2. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
 3. for overlap.

4. Do not use drainage panels as protection for waterproof membrane unless approved by factory-authorized service representative of waterproofing membrane manufacturer. Submit approval if so used.

- L. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding 6 inches . Thoroughly compact each layer. Fill to finish grade.

3.9 LANDSCAPING DRAINAGE INSTALLATION

- A. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
- B. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- C. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches .
- D. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 inches between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with [adhesive] [or] [tape].
- E. Install drainage conduits as indicated in Part 3 "Piping Installation" Article for landscaping subdrainage with horizontal distance of at least 6 inches between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.
- F. Add drainage course to top of drainage conduits.
- G. After satisfactory testing, cover drainage conduit to within 12 inches of finish grade.
- H. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
- I. Place layer of [flat-style geotextile filter fabric] [roofing felt] over top of drainage course, overlapping edges at least 4 inches.
- J. Place layer of flat-style geotextile filter fabric over top of drainage course, overlapping edges at least 4 inches .
- K. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding 6 inches . Thoroughly compact each layer. Fill to finish grade.

3.10 PIPING INSTALLATION

- A. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
 1. Foundation Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of 36 inches , unless otherwise indicated.

2. Underslab Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent.
 3. Plaza Deck Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 1.0 percent.
 4. Lay perforated pipe with perforations down.
 5. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
- B. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
- C. Install ABS piping according to ASTM D 2321.
- D. Install PE piping according to ASTM D 2321.
- E. Install PVC piping according to ASTM D 2321.
- F. Install clay piping according to ASTM C 12 and NCPI's "Clay Pipe Engineering Manual."
- G. Install concrete piping according to ACPA's "Concrete Pipe Handbook."

3.11 PIPE JOINT CONSTRUCTION

- A. Cast-Iron Soil Pipe and Fittings: Hub and spigot, with rubber compression gaskets according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook." Use gaskets that match class of pipe and fittings.
- B. Join ABS pipe and fittings according to ASTM D 2751.
- C. Join PE pipe, tubing, and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties."
- D. Join perforated, PE pipe and fittings with couplings for soil-tight joints according to AASHTO's "Standard Specifications for Highway Bridges," Division II, Section 26.4.2.4, "Joint Properties"; or according to ASTM D 2321.
- E. Join PVC pipe and fittings according to ASTM D 3034 with elastomeric seal gaskets according to ASTM D 2321.
- F. Join perforated PVC pipe and fittings according to ASTM D 2729, with loose bell-and-spigot joints.
- G. Join perforated clay pipe and fittings with gaskets according to ASTM C 425.
- H. Join perforated concrete pipe and fittings with gaskets according to ASTM C 443.
- I. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.

3.12 CLEANOUT INSTALLATION

A. Cleanouts for Foundation Subdrainage:

1. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. In vehicular-traffic areas, use NPS 4 cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 18 by 18 by 12 inches in depth. Set top of cleanout flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
3. In nonvehicular-traffic areas, use NPS 4 PVC pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, 12 by 12 by 4 inches in depth. Set top of cleanout plug 1 inch above grade.

B. Cleanouts for Underslab Subdrainage:

1. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
2. Use NPS 4 cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.

3.13 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.
- C. Where required, connect low elevations of foundation and underslab subdrainage to stormwater sump pumps.

3.14 IDENTIFICATION

- A. Materials and their installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping.
 1. Install PE warning tape or detectable warning tape over ferrous piping.
 2. Install detectable warning tape over nonferrous piping and over edges of underground structures.

3.15 FIELD QUALITY CONTROL

- A. Testing: After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.

3.16 CLEANING

- A. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 33 4600