



DLR Group

Architecture
Engineering
Planning
Interiors

ACMA

**Beaverton School District
Beaverton, Oregon**

Bid and Permit Set

DLR Group Project No. 74-18109-00

March 14, 2019

Volume 2 of 2
Divisions 21 - 33

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Project Manual Volume 2 of 2
Divisions 21 - 33

ACMA
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EXPIRES: 12/31/2020

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PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.
6. Silicone sealants.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Jay R. Smith Mfg. Co.
- B. Description: Manufactured, galvanized cast-iron sleeve with integral clamping flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. Metraflex Company (The).
- B. Description:
 - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 2. Designed to form a hydrostatic seal of 20 psig minimum.
 - 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.
 - 4. Pressure Plates: Carbon steel.
 - 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. Metraflex Company (The).
- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.
- C. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

- A. Description: Nonshrink, 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.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
- 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 space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Use silicone sealant to seal around the outside of stack-sleeve fittings.

- B. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- or smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

3.4 SLEEVE-SEAL-FITTING INSTALLATION

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

3.5 FIELD QUALITY CONTROL

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

- C. Prepare test and inspection reports.

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 pipe sleeves.
2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.
5. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.

END OF SECTION 210517

SECTION 210518 - ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Escutcheons.
- 2. Floor plates.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. BrassCraft Manufacturing Co.; a Masco company.
 - 2. Dearborn Brass.
 - 3. Keeney Manufacturing Company (The).
 - 4. Mid-America Fittings, Inc.

2.2 ESCUTCHEONS

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

2.3 FLOOR PLATES

- A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece steel with polished, chrome-plated finish.
 - d. Bare Piping in Unfinished Service Spaces: One-piece steel with polished, chrome-plated finish.
 - e. Bare Piping in Equipment Rooms: One-piece steel with polished, chrome-plated finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor plate.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 210518

SECTION 210523 - GENERAL-DUTY VALVES FOR FIRE PROTECTION 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 butterfly valves with indicators.
2. Iron butterfly valves with indicators.
3. Check valves.
4. NRS gate valves.
5. Indicator posts.
6. Trim and drain valves.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

2.2 TWO-PIECE BALL VALVES WITH INDICATORS

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

2.3 BRONZE BUTTERFLY VALVES WITH INDICATORS

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

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

B. Description:

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

2.4 CHECK VALVES

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

1. Globe Fire Sprinkler Corporation.
2. Kennedy Valve Company; a division of McWane, Inc.
3. Matco-Norca.
4. Mueller Co.
5. NIBCO INC.
6. Reliable Automatic Sprinkler Co., Inc. (The).
7. Tyco Fire Products LP.
8. United Brass Works, Inc.
9. Venus Fire Protection Ltd.
10. Victaulic Company.
11. WATTS.

B. Description:

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

2.5 TRIM AND DRAIN VALVES

A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Apollo Flow Controls; Conbraco Industries, Inc.
2. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Design: Two piece.
 - c. Body Material: Forged brass or bronze.
 - d. Port size: Full or standard.
 - e. Seats: PTFE.
 - f. Stem: Bronze or stainless steel.
 - g. Ball: Chrome-plated brass.
 - h. Actuator: Handlever.
 - i. End Connections for Valves NPS 1 through NPS 2-1/2: Threaded ends.
 - j. End Connections for Valves NPS 1-1/4 and NPS 2-1/2: Grooved ends.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 GENERAL REQUIREMENTS FOR VALVE INSTALLATION

- A. Comply with requirements in the following Sections for specific valve installation requirements and applications:
 1. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.

2. Section 211316 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.
 - B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.
 - C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.
 - D. Install valves having threaded connections with unions at each piece of equipment arranged to allow easy access, service, maintenance, and equipment removal without system shutdown. Provide separate support where necessary.
 - E. Install valves in horizontal piping with stem at or above the pipe center.
 - F. Install valves in position to allow full stem movement.
 - G. Install valve tags. Comply with requirements in Section 210553 "Identification for Fire-Suppression Piping and Equipment" for valve tags and schedules and signs on surfaces concealing valves; and the NFPA standard applying to the piping system in which valves are installed. Install permanent identification signs indicating the portion of system controlled by each valve.
 - H. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.
 - I. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION 210523

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

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal hanger-shield inserts.
5. Fastener systems.
6. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 210516 "Expansion Fittings and Loops for Fire-Suppression Piping" for pipe guides and anchors.
3. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for vibration isolation devices and seismic restraints.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

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

1. Detail fabrication and assembly of trapeze hangers.

2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
- B. Structural Performance: Hangers and supports for fire-suppression piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
- C. NFPA Compliance: Comply with NFPA 13.
- D. UL Compliance: Comply with UL 203.

2.2 METAL PIPE HANGERS AND SUPPORTS

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

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

A. 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, factory-fabricated components for field assembly.
- 3. Channels: Continuous slotted carbon-steel channel with inturned lips.
- 4. Channel Width: Selected for applicable load criteria.
- 5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- 7. Metallic Coating: No coating.

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, factory-fabricated components for field assembly.
- 3. Channels: Continuous slotted carbon-steel channel with inturned lips.
- 4. Channel Width: Select for applicable load criteria.
- 5. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- 7. Metallic Coating: No coating.

2.5 FASTENER SYSTEMS

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

2.6 EQUIPMENT SUPPORTS

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

2.7 MATERIALS

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

PART 3 - EXECUTION

3.1 APPLICATION

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

3.2 HANGER AND SUPPORT INSTALLATION

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

- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal strut 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. Install in accordance with approvals and listings.
 - 2. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions. Install in accordance with approvals and listings.
- F. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- M. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

3.4 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.
4. Finish welds at exposed connections, so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

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

3.6 PAINTING

- A. Touchup: Clean field welds and abraded, shop-painted areas. Paint exposed areas immediately after erecting hangers and supports. Use same materials as those used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded, shop-painted areas on miscellaneous metal are specified in Section 099113 "Exterior Painting." Section 099123 "Interior Painting."
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas, and apply galvanizing-repair paint to comply with ASTM A780/A780M.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with NFPA requirements for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Horizontal-Piping Hangers and Supports: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30.

2. Steel Pipe Clamps (MSS Type 4): For suspension of NPS 1/2 to NPS 24 if little or no insulation is required.
 3. 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 or carbon-steel plate.
- G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 if longer ends are required for riser clamps.
- H. Hanger-Rod Attachments: Comply with NFPA requirements.
- I. Building Attachments: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. C-Clamps (MSS Type 23): For structural shapes.
 3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
- J. Saddles and Shields: Comply with NFPA requirements. Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal Hanger-Shield Inserts: For supporting insulated pipe.
- K. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 210529

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE-SUPPRESSION PIPING
AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Elastomeric isolation pads.
2. Elastomeric isolation mounts.
3. Restrained elastomeric isolation mounts.
4. Pipe-riser resilient supports.
5. Resilient pipe guides.
6. Elastomeric hangers.
7. Snubbers.
8. Restraint channel bracings.
9. Seismic-restraint accessories.
10. Mechanical anchor bolts.
11. Adhesive anchor bolts.

B. Related Requirements:

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

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

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

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
 2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
 3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for fire-suppression piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For professional engineer.

- C. Welding certificates.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: See S0.1.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: See S0.1.
 - a. Component Importance Factor: 1.0.
 - b. Component Response Modification Factor: Refer to ASCE standard 7-05, Chapter 13.
 - c. Component Amplification Factor: Refer to ASCE standard 7-05, Chapter 13.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): Refer to ASCE standard 7-05, Chapter 13.
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: Refer to ASCE standard 7-05, Chapter 13.
 - 5. Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

- a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 PIPE-RISER RESILIENT SUPPORT

- A. Description: All-directional, acoustical pipe anchor consisting of two steel tubes separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
 1. Vertical-Limit Stops: Steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions.
 2. Maximum Load Per Support: 500 psig (3.45 MPa) on isolation material providing equal isolation in all directions.

2.3 RESILIENT PIPE GUIDES

- A. Description: Telescopic arrangement of two steel tubes or post-and-sleeve arrangement separated by a minimum 1/2-inch- (13-mm-) thick neoprene.
 1. Factory-Set Height Guide with Shear Pin: Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.4 SNUBBERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Kinetics Noise Control, Inc.
 2. Mason Industries, Inc.
 3. Novia; A Division of C&P.
 4. Vibration Mountings & Controls, Inc.
- B. Description: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
 1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
 2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
 3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

2.5 SEISMIC-RESTRAINT ACCESSORIES

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

1. Kinetics Noise Control, Inc.
 2. Mason Industries, Inc.
 3. TOLCO.
 4. Vibration & Seismic Technologies, LLC.
- B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.
- C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

- B. Comply with requirements in Section 077200 "Roof Accessories" for installation of equipment supports and roof penetrations.
- C. Equipment Restraints:
 - 1. Install seismic snubbers on fire-suppression equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- D. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
 - 3. Brace a change of direction longer than 12 feet (3.7 m).
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- I. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.

6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 211200 "Fire-Suppression Standpipes," Section 211313 "Wet-Pipe Sprinkler Systems," and Section 211316 "Dry-Pipe Sprinkler Systems" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:
 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 5. Test to 90 percent of rated proof load of device.
 6. Measure isolator restraint clearance.
 7. Measure isolator deflection.
 8. Verify snubber minimum clearances.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

END OF SECTION 210548

SECTION 210553 - IDENTIFICATION FOR FIRE-SUPPRESSION PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Carlton Industries, LP.

- d. Champion America.
 - e. Craftmark Pipe Markers.
 - f. emedco.
 - g. Kolbi Pipe Marker Co.
 - h. LEM Products Inc.
 - i. Seton Identification Products.
2. Material and Thickness: Brass, 0.032 inch thick, with predrilled holes for attachment hardware.
 3. Letter Color: Black.
 4. Background Color: White.
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. Brimar Industries, Inc.
 - c. Carlton Industries, LP.
 - d. Champion America.
 - e. Craftmark Pipe Markers.
 - f. emedco.
 - g. Kolbi Pipe Marker Co.
 - h. LEM Products Inc.
 - i. Marking Services, Inc.
 - j. Seton Identification Products.
2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
3. Letter Color: Black.
4. Background Color: White.
5. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
6. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
7. 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.
8. Fasteners: Stainless-steel rivets or self-tapping screws.
9. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- C. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), and the Specification Section number and title where equipment is specified.
- D. Equipment-Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules) and the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. Brimar Industries, Inc.
 - 3. Carlton Industries, LP.
 - 4. Champion America.
 - 5. Craftmark Pipe Markers.
 - 6. emedco.
 - 7. LEM Products Inc.
 - 8. Marking Sevicees Inc.
 - 9. National Marker Company.
 - 10. Seton Identification Products.
 - 11. Stranco, Inc.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, with predrilled holes for attachment hardware.
- C. Letter Color: Black.
- D. Background Color: White.
- E. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- F. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- G. 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.
- H. Fasteners: Stainless-steel.
- I. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

- J. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 VALVE TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Actioncraft Products, Inc.; a division of Industrial Test Equipment Co., Inc.
 - 2. Brady Corporation.
 - 3. Brimar Industries, Inc.
 - 4. Carlton Industries, LP.
 - 5. Champion America.
 - 6. Craftmark Pipe Markers.
 - 7. emedco.
 - 8. Kolbi Pipe Marker Co.
 - 9. LEM Products Inc.
 - 10. Marking Seivics Inc.
 - 11. Seton Identification Products.
- B. Description: Stamped or engraved with 1/4-inch letters for piping-system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032 inch thick, with predrilled holes for attachment hardware.
 - 2. Fasteners: Brass beaded chain.
 - 3. Valve-Tag Color: Safety Red.
 - 4. Letter Color: White.
- C. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 GENERAL INSTALLATION REQUIREMENTS

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

3.3 EQUIPMENT LABEL INSTALLATION

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

3.4 PIPE LABEL INSTALLATION

- A. Piping: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Stenciled Pipe-Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Pipe-Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection excluding short takeoffs. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations and on both sides of through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit a view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.5 VALVE-TAG INSTALLATION

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

END OF SECTION 210553

SECTION 211313 - WET-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

- B. Related Requirements:

1. Section 210523 "General-Duty Valves for Fire Protection Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

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

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

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

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

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Domestic water piping.
 - 2. Compressed air piping.
 - 3. HVAC ductwork.
 - 4. HVAC hydronic piping.
 - 5. Items penetrating finished ceiling include the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
- B. Design Data:
 - 1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- C. Field Test Reports:
 - 1. 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."
 - 2. Fire-hydrant flow test report.
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13.

B. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design wet-pipe sprinkler systems.

1. Available fire-hydrant flow test records indicate the following conditions:

- a. Static Pressure at Residual Fire Hydrant R: 78 psi
- b. Measured Flow at Flow Fire Hydrant F: 1930 gpm.
- c. Residual Pressure at Residual Fire Hydrant R: 62 psi.

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

- a. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
- b. Sprinkler Occupancy Hazard Classifications:

- 1) As indicated and as required by NFPA 13 and AHJ, whichever requirement is more stringent.

3. Minimum Density for Automatic-Sprinkler Piping Design:

- a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
- b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
- c. Ordinary-Hazard, Group 2 Occupancy: 0.20 gpm over 1500-sq. ft. (8.1 mm/min. over 139-sq. m) area.

4. Maximum Protection Area per Sprinkler:

- a. Office Spaces: 225 sq. ft.

- b. Storage Areas: 130 sq. ft.
- c. Mechanical Equipment Rooms: 130 sq. ft.
- d. Electrical Equipment Rooms: 130 sq. ft.
- e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.

- D. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.2 STEEL PIPE AND FITTINGS

- A. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A135/A135M; ASTM A795/A795M, Type E; or ASME B36.10M wrought steel, with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 10, Black-Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, Schedule 10 in NPS 5 (DN 125) and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10 (DN 150 to DN 250), plain end.
- C. Galvanized- and Black-Steel Pipe Nipples: ASTM A733, made of ASTM A53/A53M, standard-weight, seamless steel pipe with threaded ends.
- D. Malleable- or Ductile-Iron Unions: UL 860.
- E. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Victaulic Company.
 - 2. Pressure Rating: 175-psig (1200-kPa) minimum.
 - 3. Galvanized Painted Grooved-End Fittings for Steel Piping: ASTM A47/A47M, malleable-iron casting or ASTM A536, ductile-iron casting, with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

2.3 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating:
 - 1. Standard-Pressure Piping Specialty Valves: 175-psig minimum.
- C. Body Material: Cast or ductile iron.

- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Alarm Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Viking Corporation.
 - 2. Standard: UL 193.
 - 3. Design: For horizontal or vertical installation.
 - 4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, and fill-line attachment with strainer.
 - 5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
 - 6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Automatic (Ball Drip) Drain Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire Products LP.
 - 2. Standard: UL 1726.
 - 3. Pressure Rating: 175-psig minimum.
 - 4. Type: Automatic draining, ball check.
 - 5. Size: NPS 3/4.
 - 6. End Connections: Threaded.

2.4 SPRINKLER PIPING SPECIALTIES

- A. Branch Outlet Fittings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Tyco Fire Products LP.
 - c. Victaulic Company.
 - 2. Standard: UL 213.
 - 3. Pressure Rating: 175-psig minimum.

4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Tyco Fire Products LP.
 - b. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Potter Roemer LLC.
2. Standard: UL 199.
3. Pressure Rating: 175 psig.
4. Body Material: Brass.
5. Size: Same as connected piping.
6. Inlet: Threaded.
7. Drain Outlet: Threaded and capped.
8. Branch Outlet: Threaded, for sprinkler.

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Triple R Specialty.
 - c. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.

5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fivalco Inc.
 - b. Victaulic Company.
2. Standard: UL 1474.
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.
4. Pressure Rating: 175-psig minimum.
5. Size: Same as connected piping, for sprinkler.

2.5 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Reliable Automatic Sprinkler Co., Inc. (The).
 2. Tyco Fire Products LP.
 3. Venus Fire Protection Ltd.
 4. Viking Corporation.
- B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- C. Pressure Rating for Residential Sprinklers: 175-psig maximum.
- D. Pressure Rating for Automatic Sprinklers: 175-psig minimum.
- E. Automatic Sprinklers with Heat-Responsive Element:
 1. Early-Suppression, Fast-Response Applications: UL 1767.
 2. Nonresidential Applications: UL 199.
 3. Characteristics: Nominal 1/2-inch orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- F. Sprinkler Finishes: Chrome plated bronze and painted.
- G. Special Coatings: Wax lead and corrosion-resistant paint.
- H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
2. Sidewall Mounting: Chrome-plated steel, one piece, flat.

I. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire Products LP.
 - c. Viking Corporation.
2. Standard: UL 199.
3. Type: Wire cage with fastening device for attaching to sprinkler.

2.6 ALARM DEVICES

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

B. Water-Motor-Operated Alarm:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Viking Corporation.
2. Standard: UL 753.
3. Type: Mechanically operated, with Pelton wheel.
4. Alarm Gong: Cast aluminum with red-enamel factory finish.
5. Size: 8-1/2-inches diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4.
8. Outlet: NPS 1 drain connection.

C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ADT Security Services, Inc.
 - b. McDonnell & Miller.
 - c. Potter Electric Signal Company, LLC.
 - d. System Sensor.
 - e. Viking Corporation.
 - f. WATTS.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.

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

D. Valve Supervisory Switches:

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

2.7 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. AGF Manufacturing, Inc.
 2. AMETEK, Inc.
 3. Ashcroft Inc.
 4. Brecco Corporation.
 5. WIKA Instrument Corporation.
- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0- to 250-psig minimum.
- E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 SERVICE-ENTRANCE PIPING

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

3.3 PIPING INSTALLATION

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

- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- K. Install alarm devices in piping systems.
- L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- N. Fill sprinkler system piping with water.
- O. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- P. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.
- I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
- J. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
 - 1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.
- K. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.
- L. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- M. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.5 VALVE AND SPECIALTIES INSTALLATION

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

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

3.6 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.
- B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.
- C. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 IDENTIFICATION

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

3.8 FIELD QUALITY CONTROL

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

3.9 CLEANING

- A. Clean dirt and debris from sprinklers.

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

3.10 DEMONSTRATION

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

3.11 PIPING SCHEDULE

- A. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends, cast-iron threaded fittings, and threaded joints.
- B. Standard-pressure, wet-pipe sprinkler system, NPS 2 and smaller, shall be the following:
 - 1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 and larger, shall be one of the following:
 - 1. Standard-weight, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
 - 2. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.

3.12 SPRINKLER SCHEDULE

- A. Use sprinkler types in subparagraphs below for the following applications:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended Ceilings: Concealed sprinklers.
 - 3. Wall Mounting: Concealed Sidewall sprinklers.
- B. Provide sprinkler types in subparagraphs below with finishes indicated.
 - 1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
 - 2. Upright Pendent Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

END OF SECTION 211313

SECTION 211316 - DRY-PIPE SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Pipes, fittings, and specialties.
 - 2. Specialty valves.
 - 3. Sprinkler specialty pipe fittings.
 - 4. Sprinklers.
 - 5. Alarm devices.
 - 6. Pressure gages.

- B. Related Requirements:

- 1. Section 210523 "General-Duty Valves for Fire Protection Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Dry-pipe sprinkler system piping designed to operate at working pressure of 175-psig (1200-kPa) maximum.

1.4 ACTION SUBMITTALS`

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

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

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

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

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

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Domestic water piping.
 - 2. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
- B. Qualification Data: For qualified Installer.
- C. Design Data:
 - 1. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.
- D. Field Test Reports:
 - 1. Fire-hydrant flow test report.
 - 2. Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping."
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing sprinkler systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTIONS

- A. 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.

2.2 PERFORMANCE REQUIREMENTS

- A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
 1. NFPA 13.
- B. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
- C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design dry-pipe sprinkler systems.
 1. Available fire-hydrant flow test records indicate the following conditions:
 - a. See section 211313.
- D. Sprinkler system design shall be approved by authorities having jurisdiction.
 1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
 2. Sprinkler Occupancy Hazard Classifications:
 - a. As indicated and as required by NFPA 13 and AHJ, whichever requirement is more stringent.
 3. Minimum Density for Automatic-Sprinkler Piping Design:
 - a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
 - b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
 - c. Special Occupancy Hazard: As determined by authorities having jurisdiction.

4. Maximum Protection Area per Sprinkler: According to UL listing or Item 5, whichever is more stringent.
5. Maximum Protection Area per Sprinkler:
 - a. Office Spaces: 120 sq. ft. (11.1 sq. m).
 - b. Storage Areas: 130 sq. ft. (12.1 sq. m).
 - c. Mechanical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
 - d. Electrical Equipment Rooms: 130 sq. ft. (12.1 sq. m).
 - e. Other Areas: According to NFPA 13 recommendations unless otherwise indicated.
- E. Seismic Performance: Sprinkler piping shall withstand the effects of earthquake motions determined according to NFPA 13 and ASCE/SEI 7.

2.3 STEEL PIPE AND FITTINGS

- A. Standard-Weight, Galvanized-Steel Pipe: ASTM A 53/A 53M,. Pipe ends may be factory or field formed to match joining method.
- B. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- C. Galvanized-Steel Couplings: ASTM A 865/A 865M, threaded.
- D. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- E. Cast-Iron Flanges: ASME B16.1, Class 125.
- F. Grooved-Joint, Steel-Pipe Appurtenances:
 1. Grooved Joint is not allowed.

2.4 SPECIALTY VALVES

- A. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- B. Pressure Rating:
 1. Standard-Pressure Piping Specialty Valves: 175-psig (1200-kPa) minimum.
- C. Body Material: Cast or ductile iron.
- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Dry-Pipe Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Globe Fire Sprinkler Corporation.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco Fire Products LP.
 - d. Viking Corporation.
2. Standard: UL 260.
3. Design: Differential-pressure type.
4. 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.
5. Standard: UL 260.
6. Type: Automatic device to maintain minimum air pressure in piping.
7. 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 (95- to 410-kPa) adjustable range, and 175-psig (1200-kPa) outlet pressure.
8. Air Compressor:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Gast Manufacturing Inc.
 - 2) General Air Products, Inc.
 - 3) Viking Corporation.
 - b. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 - c. Motor Horsepower: Fractional.
 - d. Power: 120-V ac, 60 Hz, single phase.

G. Automatic (Ball Drip) Drain Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire Products LP.
2. Standard: UL 1726.
3. Pressure Rating: 175-psig (1200-kPa) minimum.
4. Type: Automatic draining, ball check.
5. Size: NPS 3/4 (DN 20).
6. End Connections: Threaded.

2.5 SPRINKLER PIPING SPECIALTIES

- A. General Requirements for Dry-Pipe System Fittings: UL listed for dry-pipe service.
- B. Branch Outlet Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. National Fittings, Inc.
 - b. Tyco Fire Products LP.
 2. Standard: UL 213.
 3. Pressure Rating: 175-psig (1200-kPa) minimum.
 4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
 5. Type: Mechanical-tee and -cross fittings.
 6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
 7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
 8. Branch Outlets: Grooved, plain-end pipe, or threaded.
- C. Flow Detection and Test Assemblies:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Reliable Automatic Sprinkler Co., Inc. (The).
 - c. Tyco Fire Products LP.
 2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 3. Pressure Rating: 175-psig (1200-kPa) minimum.
 4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded.
- D. Sprinkler Inspector's Test Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AGF Manufacturing, Inc.
 - b. Triple R Specialty.
 - c. Tyco Fire Products LP.
 - d. Viking Corporation.
 2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 3. Pressure Rating: 175-psig (1200-kPa) minimum.
 4. Body Material: Cast- or ductile-iron housing with sight glass.
 5. Size: Same as connected piping.
 6. Inlet and Outlet: Threaded.

2.6 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Globe Fire Sprinkler Corporation.
 - 2. Reliable Automatic Sprinkler Co., Inc. (The).
 - 3. Tyco Fire Products LP.
 - 4. Venus Fire Protection Ltd.
 - 5. Viking Corporation.
- B. Listed in UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
- C. Pressure Rating for Automatic Sprinklers: 175-psig (1200-kPa) minimum.
- D. Automatic Sprinklers with Heat-Responsive Element:
 - 1. Nonresidential Applications: UL 199.
 - 2. Residential Applications: UL 1626.
 - 3. Characteristics: Nominal 1/2-inch (12.7-mm) orifice with Discharge Coefficient K of 5.6, and for "Ordinary" temperature classification rating unless otherwise indicated or required by application.
- E. Sprinkler Finishes: Chrome plated bronze and painted.
- F. Special Coatings: Wax lead and corrosion-resistant paint.
- G. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
 - 1. Ceiling Mounting: Chrome-plated steel, one piece, flat.
 - 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- H. Sprinkler Guards:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire Products LP.
 - c. Viking Corporation.
 - 2. Standard: UL 199.
 - 3. Type: Wire cage with fastening device for attaching to sprinkler.

2.7 ALARM DEVICES

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

B. Water-Motor-Operated Alarm:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Globe Fire Sprinkler Corporation.
 - b. Tyco Fire Products LP.
 - c. Viking Corporation.
2. Standard: UL 753.
3. Type: Mechanically operated, with Pelton wheel.
4. Alarm Gong: Cast aluminum with red-enamel factory finish.
5. Size: 10-inch (250-mm) diameter.
6. Components: Shaft length, bearings, and sleeve to suit wall construction.
7. Inlet: NPS 3/4 (DN 20).
8. Outlet: NPS 1 (DN 25) drain connection.

C. Valve Supervisory Switches:

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

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 WATER-SUPPLY CONNECTIONS

- A. Connect sprinkler piping to building's interior water-distribution piping. Comply with requirements for interior piping in Section 221116 "Domestic Water Piping."

- B. Install shutoff valve, pressure gage, drain, and other accessories indicated at connection to water-distribution piping.
- C. Install shutoff valve, check valve, pressure gage, and drain at connection to water supply.

3.3 PIPING INSTALLATION

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

- M. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- N. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- O. Drain dry-pipe sprinkler piping.
- P. Pressurize and check dry-pipe sprinkler system piping and air compressors.
- Q. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- R. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- S. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.4 JOINT CONSTRUCTION

- A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system's pressure rating for aboveground applications unless otherwise indicated.
- B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.
- C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.
- D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.
- G. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

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

3.5 VALVE AND SPECIALTIES INSTALLATION

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

3.6 SPRINKLER INSTALLATION

- A. Install sprinklers with water supply from heated space. Do not install pendent or sidewall sprinklers in areas subject to freezing.
- B. Install sprinklers into flexible, sprinkler hose fittings, and install hose into bracket on ceiling grid.

3.7 IDENTIFICATION

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

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
4. Energize circuits to electrical equipment and devices.
5. Start and run air compressors.
6. Coordinate with fire-alarm tests. Operate as required.
7. Coordinate with fire-pump tests. Operate as required.
8. Verify that equipment hose threads are same as local fire department equipment.

B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.9 CLEANING

A. Clean dirt and debris from sprinklers.

B. Only sprinklers with their original factory finish are acceptable. Remove and replace any sprinklers that are painted or have any other finish than their original factory finish.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

3.11 PIPING SCHEDULE

A. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.

B. Standard-pressure, dry-pipe sprinkler system, shall be the following:

1. Standard-weight, galvanized-steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.

3.12 SPRINKLER SCHEDULE

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

1. Spaces Subject to Freezing: Dry concealed sprinklers.

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

1. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

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END OF SECTION 211316

SECTION 220513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.

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 SINGLE-PHASE MOTORS

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

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 220513

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. GPT; an EnPro Industries company.
- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.

2.2 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. GPT; an EnPro Industries company.
 4. Metraflex Company (The).
- B. Description:
1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 2. Designed to form a hydrostatic seal of 20 psig minimum.
 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 4. Pressure Plates: Carbon steel.
 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. GPT; an EnPro Industries company.
 4. Metraflex Company (The).
- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall.
- C. Plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Description: Nonshrink, 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.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. 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.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

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

3.3 SLEEVE-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. Use grout to seal the space around outside of sleeve-seal fittings.

3.4 FIELD QUALITY CONTROL

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

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

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SECTION 220518 - ESCUTCHEONS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 ESCUTCHEONS

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

2.3 FLOOR PLATES

- A. Split Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of insulated piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Insulated Piping: One-piece stamped steel or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece cast brass with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: One-piece cast brass with polished, chrome-plated finish.
 - f. Bare Piping in Equipment Rooms: One-piece cast brass with polished, chrome-plated finish.
 - g. Bare Piping in Equipment Rooms: One-piece stamped steel or split-plate, stamped steel with exposed-rivet hinge with polished, chrome-plated finish.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor plate.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 220518

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Light-activated thermometers.
 - 2. Thermo
 - 3. Gage attachments.
 - 4. Test plugs.
 - 5. Test-plug kits.

- B. Related Requirements:

- 1. Section 221119 "Domestic Water Piping Specialties" for water meters.
 - 2. Section 221513 "General-Service Compressed-Air Piping" for compressed air gages.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 LIGHT-ACTIVATED THERMOMETERS

- A. Direct-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flo Fab Inc.
 - b. REOTEMP Instrument Corporation.
 - c. Terice, H. O. Co.
 - d. Weiss Instruments, Inc.
 - e. WIKA Instrument Corporation.
 - f. Winters Instruments - U.S.
2. Case: Metal; 9-inch nominal size unless otherwise indicated.
3. Scale(s): Deg F and deg C.
4. Case Form: Adjustable angle.
5. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
7. Display: Digital.
8. Accuracy: Plus or minus 2 deg F.

B. Remote-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Weiss Instruments, Inc.
 - c. Winters Instruments - U.S.
2. Case: Plastic, for wall mounting.
3. Scale(s): Deg F and deg C.
4. Sensor: Bulb and thermister wire.
 - a. Design for Thermowell Installation: Bare stem.
5. Display: Digital.
6. Accuracy: Plus or minus 2 deg F.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Type: Stepped shank unless straight or tapered shank is indicated.
5. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
6. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.

7. Bore: Diameter required to match thermometer bulb or stem.
8. Insertion Length: Length required to match thermometer bulb or stem.
9. Lagging Extension: Include on thermowells for insulated piping and tubing.
10. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

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

2.3 PRESSURE GAGES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ametek U.S. Gauge.
 - b. Ashcroft Inc.
 - c. Eugene Ernst Products Co.
 - d. KOBOLD Instruments, Inc.
 - e. Miljoco Corporation.
2. Standard: ASME B40.100.
3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass or plastic.
10. Ring: Brass.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 TEST PLUGS

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

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

- B. Description: Test-station fitting made for insertion into piping tee fitting.
- C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
- D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.
- E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- H. Install remote-mounted pressure gages on panel.
- I. Install valve and snubber in piping for each pressure gage for fluids.
- J. Install test plugs in piping tees. Install test plugs in hot water circulation (HWC) piping downstream of balancing valve shown on plans.
- K. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlet and outlet of each domestic hot-water storage tank.
 - 3. Downstream of mixing valve.
- L. 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.

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 and hot-water storage tank shall be the following:
 1. Direct-mounted, light-activated type.
- B. 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 (Minus 20 to plus 50 deg C).
- B. Scale Range for Domestic Hot-Water Piping: 30 to 240 deg F (0 to plus 115 deg C).

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each water service into building shall be the following:
 1. Liquid-filled, direct-mounted, metal case.
- B. Pressure gages at inlet and outlet of each water pressure-reducing valve shall be the following:
 1. Sealed, direct-mounted, metal case.
- C. Pressure gages at suction and discharge of each domestic water pump shall be the following:
 1. Liquid-filled, direct-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 160 psi and 0 to 1100 kPa.

- B. Scale Range for Domestic Water Piping: 0 to 100 psi and 0 to 600 kPa.

END OF SECTION 220519

SECTION 220523.12 - BALL 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.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.5 for flanges on steel valves.
 - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 5. ASME B16.18 for solder-joint connections.
 - 6. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 and NSF 372 for valve materials for potable-water service.
- D. 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.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
 - 2. Handlever: For quarter-turn valves smaller than NPS 4.
- H. Valves in Insulated Piping:
 - 1. Include 2-inch stem extensions.
 - 2. Extended operating handles of nonthermal-conductive material and protective sleeves that allow operation of valves without breaking vapor seals or disturbing insulation.
 - 3. Memory stops that are fully adjustable after insulation is applied.

2.2 BRONZE BALL VALVES

- A. Bronze Ball Valves, Two-Piece with Full Port, and Bronze or Brass or Bronze Trim, Threaded or Soldered Ends:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Red-White Valve Corporation.

- d. WATTS.
- 2. Description:
 - a. Standard: MSS SP-110 or MSS-145.
 - b. CWP Rating: 600 psig.
 - c. Body Design: Two piece.
 - d. Body Material: Bronze.
 - e. Ends: Threaded and soldered.
 - f. Seats: PTFE.
 - g. Stem: Bronze or brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 LOW-PRESSURE, COMPRESSED-AIR VALVE SCHEDULE (150 PSIG OR LESS)

- A. Pipe NPS 2-1/2 and Smaller:
 - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 - 2. Bronze ball valves, two-piece with full port and brass or bronze trim.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

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

END OF SECTION 220523.12

SECTION 220523.13 - BUTTERFLY 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. Iron, single-flange butterfly valves.
 - 2. Iron, grooved-end butterfly valves.
 - 3. Chainwheels.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set butterfly valves closed or slightly open.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

- 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. ASME Compliance:
 - 1. ASME B16.1 for flanges on iron valves.
 - 2. ASME B16.5 for flanges on steel valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B31.9 for building service piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. NSF Compliance: NSF 61 Annex G for valve materials for potable-water service.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
 - 1. Gear Actuator: For valves NPS 8 (DN 200) and larger.
 - 2. Handlever: For valves NPS 6 (DN 150) and smaller.
- H. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

- A. Iron, Single-Flange Butterfly Valves with Aluminum-Bronze Disc:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Red-White Valve Corp.
 - d. WATTS.
 - 2. Description:
 - a. Standard: MSS SP-67, Type I.

- b. CWP Rating: 200 psig (1380 kPa).
- c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
- e. Seat: EPDM.
- f. Stem: One- or two-piece stainless steel.
- g. Disc: Aluminum bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements in Section 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

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

3.4 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Larger:

1. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM seat, aluminum-bronze disc.

END OF SECTION 220523.13

SECTION 220523.14 - CHECK 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 swing check valves.
 - 2. Iron swing check valves.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene-diene terpolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve.
 - 1. Certification that products comply with NSF 61.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set check valves in either closed or open position.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use 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. 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.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- E. 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.
- F. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- G. Valve Sizes: Same as upstream piping unless otherwise indicated.
- H. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE SWING CHECK VALVES

- A. Bronze Swing Check Valves with Bronze Disc, Class 125:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Red-White Valve Corp.
 - d. WATTS.
 - 2. Description:
 - a. Standard: MSS SP-80, Type 3.

- b. CWP Rating: 200 psig.
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B62, bronze.
- e. Ends: Threaded or soldered. See valve schedule articles.
- f. Disc: Bronze.

2.3 IRON SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Red-White Valve Corp.
 - d. 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 A126, gray iron with bolted bonnet.
 - e. Ends: Flanged or threaded. See valve schedule articles.
 - f. Trim: Bronze.
 - g. 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 220553 "Identification for Plumbing Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

- A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. 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. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. End Connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded or soldered or press-ends.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded.

3.5 DOMESTIC HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Bronze swing check valves with bronze disc, Class 125, with soldered end connections.
- B. Pipe NPS 2-1/2 and Larger:

1. Iron swing check valves with metal seats, Class 125, with threaded or flanged end connections.

END OF SECTION 220523.14

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

1.2 PERFORMANCE REQUIREMENTS

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper- or epoxy-coated-steel, factory-fabricated components.

2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel or stainless steel.

2.2 TRAPEZE PIPE HANGERS

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

2.3 METAL FRAMING SYSTEMS

- A. Manufacturer Metal Framing Systems:

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

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- B. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

2.6 PIPE STANDS

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

2.7 PIPE POSITIONING SYSTEMS

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

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See other sections of the specifications for curbs.
- G. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture.
- H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

- M. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- O. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Saddles exposed to view shall have a paint grip surface.
 - b. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
 - 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

- A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 METAL FABRICATIONS

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

3.4 ADJUSTING

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

3.5 PAINTING

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

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and metal trapeze pipe hangers and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications.
- G. Use copper- or epoxy-plated pipe hangers and copper attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).

10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.
- L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

- M. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb (340 kg).
 - b. Medium (MSS Type 32): 1500 lb (680 kg).
 - c. Heavy (MSS Type 33): 3000 lb (1360 kg).
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- N. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Saddles and shields exposed to view shall have a paint grip surface.
 2. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 3. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 4. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
- O. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- P. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

- Q. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- R. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.
- S. Use PEX-a Support on all horizontal runs of PEX piping. No bare horizontal PEX pipe support is allowed.

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS 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. Pipe-riser resilient supports.
2. Resilient pipe guides.
3. Restraint channel bracings.
4. Restraint cables.
5. Seismic-restraint accessories.
6. Mechanical anchor bolts.
7. Adhesive anchor bolts.

B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

- a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
 1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.
- C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
 3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For professional engineer and testing agency.

- C. Welding certificates.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: See S0.1.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: See S0.1.
 - a. Component Importance Factor: 1.0.
 - b. Component Response Modification Factor: Refer to ASCE Standard 7-10, Chapter 13.
 - c. Component Amplification Factor: Refer to ASCE Standard 7-10, Chapter 13.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): See S0.1.
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: See S0.1.
 - 5. Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 RESTRAINT CHANNEL BRACINGS

- A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

- A. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.
- C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

- A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.

- G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- K. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:
 - 1. Material and Thickness: Brass, 0.032-inch stainless steel, 0.025-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

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

2.2 WARNING SIGNS AND LABELS

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

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.

- B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings; also include pipe size and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.

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

2.5 WARNING TAGS

- A. Description: Preprinted or partially preprinted accident-prevention tags of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches.
 - 2. Fasteners: Reinforced grommet and wire or string.
 - 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Safety yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of 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. Piping Color Coding: Painting of piping is specified in Section 099123 "Interior Painting."
- B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels, complying with ASME A13.1, with painted, color-coded bands or rectangles on each piping system.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- C. Pipe Label Locations: Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs 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. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- D. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes, including pipes where flow is allowed in both directions.
- E. Pipe Label Color Schedule:
 - 1. Domestic Water Piping
 - a. Background: Safety green.

- b. Letter Colors: White.
- 2. Sanitary Waste and vent, and Storm Drainage Piping:
 - a. Background Color: Safety white.
 - b. Letter Color: Black.

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. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 2 inches, round.
 - b. Hot Water: 2 inches, round.
 - 2. Valve-Tag Colors:
 - a. Cold Water: Natural.
 - b. Hot Water: Natural.
 - 3. Letter Colors:
 - a. Cold Water: Black.
 - b. Hot Water: Black.
- C. All valves above ceilings require labels clearly marked on the ceiling grid or access panel with a printed label.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 220553

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following plumbing piping services:
 - 1. Domestic cold-water piping.
 - 2. Domestic hot-water piping.
 - 3. Domestic recirculating hot-water piping.
 - 4. Supplies and drains for handicap-accessible lavatories and sinks.
 - 5. Roof drains and rainwater leaders.
- B. Related Sections:
 - 1. Division 23 Section "HVAC Insulation."

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- 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.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

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

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

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.
- B. Materials on site shall be stored inside, protected from weather conditions and shall not be subjected to direct, or indirect, moisture. Any insulation which has been subjected to moisture shall be removed from site and shall not be used.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- 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 "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation 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. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. 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 I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Friendly Feel Duct Wrap.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; SOFTR All-Service Duct Wrap.
- F. Mineral-Fiber, Preformed Pipe Insulation:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000-Degree Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 - 2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA, Inc.; Aero seal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

3. Use adhesive that complies 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," including 2004 Addenda.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Use adhesive that complies 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," including 2004 Addenda.
- D. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Use adhesive that complies 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," including 2004 Addenda.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies 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," including 2004 Addenda.

2.3 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that 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," including 2004 Addenda.

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

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that 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," including 2004 Addenda.

2.4 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.

2.5 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.6 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.

7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.

2.7 SECUREMENTS

- A. Bands:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
 2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 1/2 inch wide with wing seal or closed seal.
 3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal or closed seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- C. Wire: 0.080-inch nickel-copper alloy.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire.
 - b. Childers Products.

2.8 PROTECTIVE SHIELDING GUARDS

- A. Protective Shielding Pipe Covers:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Engineered Brass Company.

- b. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
 - c. McGuire Manufacturing.
 - d. Plumberex.
 - e. Truebro; a brand of IPS Corporation.
 - f. Zurn Industries, LLC; Tubular Brass Plumbing Products Operation.
- 2. Description: Manufactured plastic piping covers for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.
 - a. Material: Rigid, high impact stain resistant PVC, 0.125 in wall thickness.
 - b. Burning Characteristics: ASTM D-635 Self extinguished Self extinguished 0 sec (ATB) mm (AEB).
 - c. Bacteria/Fungus Resistance: 0 growth when tested in accordance with ASTM G21 and G22.

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.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
 - 1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 - 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- 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.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in 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 Division 07 Section "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:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe

- insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 - 1. Install pipe insulation to outer diameter of pipe flange.
 - 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 - 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 - 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 - 1. Install mitered sections of pipe insulation.
 - 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 - 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 - 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 - 3. Install insulation to flanges as specified for flange insulation application.
 - 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.7 INSTALLATION OF MINERAL-FIBER INSULATION

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

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FIELD-APPLIED JACKET INSTALLATION

A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.9 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe and fittings, two locations of strainers, and three locations of valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

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

3.12 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:
 - 1. NPS 1-1/4 and Smaller Insulation shall be:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
 - 2. NPS 1-1/2 and Larger Insulation shall be:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- B. Roof Drain and Overflow Drain Bodies:
 - 1. All Pipe Sizes: Insulation shall be the following for min. length of 30 feet from roof drain bowl:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Domestic Hot and Recirculated Hot Water (Potable):

1. NPS 1-1/4 and Smaller Insulation shall be:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
2. NPS 1-1/2 and Larger Insulation shall be:
 - a. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.

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

1. All Pipe Sizes: Insulation shall be protective shielding guards.

E. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60 Deg F:

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

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 1. None.
- D. Piping, Exposed, Including Valves:
 1. PVC 20 mils thick, within 96 inches of finished floor and areas subject to abuse.

END OF SECTION 220719

SECTION 220800 – PLUMBING COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes general requirements that apply to implementation of commissioning of Plumbing systems and components. It will assist operating staff training and familiarization with new systems. It will serve as a tool to reduce post-occupancy critical systems operational difficulty or failure. It will, also, be used to develop test protocol and record the associated test data in an effort to advance the building systems from a state of substantial completion to operation.
- B. All plumbing systems in the project shall perform in accordance with the design intent and the Owner's operational needs.
- C. The Commissioning Process Overview, applying to the plumbing systems and plumbing commissioning team members, can be found in specifications section 019113, General Commissioning Requirements.
- D. Systems to be commissioned:
 - 1. Plumbing system and all integral equipment controls. All plumbing systems shall be commissioned, including, but not limited to:
 - a. Domestic hot water systems

1.2 RESPONSIBILITIES

- A. Overview: The responsibilities of the plumbing commissioning team members in the commissioning process are summarized in specifications section 019113, General Commissioning Requirements.

1.3 SUBMITTALS

- A. Other Equipment and System Information.
 - 1. When not included with the standard submittals, the Trade Subcontractors shall provide to the Commissioning Provider requested shop drawings, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures and control drawings. In addition, the manufacturer installation and checkout materials that are shipped inside the equipment and the field checkout forms to be used by the factory or field technicians shall be submitted to the Commissioning Provider. This documentation may be required prior to the normal O&M manual submittals.

- B. All equipment and system documentation requested by the Commissioning Provider shall be included by the Trade Subcontractors later in the O&M manuals.
- C. The Trade Subcontractors shall submit startup forms and procedures.

1.4 QUALITY ASSURANCE

- A. Test Equipment:
 - 1. All standard testing equipment required for the Trade Subcontractors to perform installation, start-up and initial checkout and required functional testing shall be provided by the Trade Subcontractors.
 - 2. Special tools and instruments, only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents shall be provided.
 - 3. Instrumentation will be provided by the Subcontractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.
 - 4. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.
 - 5. Datalogging equipment required for testing equipment in support areas shall be provided and used by the Commissioning Provider.

1.5 COORDINATION

- A. Commissioning Team: The members of the commissioning team consist of the Commissioning Provider, the Owner/Owner Representative, the GC, the Architect and Design Engineers, the mechanical contractor, the electrical contractor, the plumbing contractor, the testing adjusting and balancing contractor, the controls contractor, any other installing subcontractors or suppliers of commissioned equipment or systems and the facility or plant operator/engineer.

PART 2 - PRODUCTS NOT USED

PART 3 - EXECUTION

3.1 MEETINGS

- A. Kick-off Meeting: The Commissioning Provider will schedule, plan and conduct a commissioning kick-off meeting with the entire commissioning team in attendance, including the controls, electrical, plumbing, mechanical, adjusting and balancing and other appropriate Trade Subcontractors and the facility operator or Owner Representative in attendance. Prior to this meeting, the commissioning plan will be distributed to all members. The commissioning plan, the overall commissioning process and general responsibilities of each team member,

reporting and communication protocols and next steps will be discussed. Meeting minutes will be distributed to all parties by the Commissioning Provider.

- B. Miscellaneous Meetings: Deficiencies identified through the commissioning process shall be discussed, as needed, in portions of regular construction meetings. Meetings dedicated to deficiencies or commissioning: status, coordination and planning shall also be conducted, if needed. The Commissioning Provider will plan, conduct and take minutes at commissioning meetings. When practical, commissioning meetings will be an appendage to regular construction meetings. All commissioning meetings shall be attended by the GC, the mechanical and the controls subcontractor. Selected meetings shall require the attendance of the electrical, plumbing, fire alarm, TAB or other trades of commissioned systems.
- C. Controls Integration Meeting: The Commissioning Provider coordinates the meeting to go over the control drawings, sequences of operation included in the controls submittal. This meeting is held prior to the approval of the controls submittal. The intent is to clarify control related issues for the controls contractor, mechanical, plumbing, and electrical contractor, facility staff and Commissioning Provider prior to startup, testing and balancing and functional testing.
 - 1. The controls contractor shall attend the meeting. The mechanical, electrical and general contractor shall attend when issues regarding equipment they are responsible for are discussed. The control technicians attending the meetings must be the same technicians that are/will install and program the DDC system.
 - 2. Primary issues discussed and clarified are:
 - a. Control drawing content
 - b. Point database (points (monitored points, software points, naming conventions, alarms, report format)
 - c. Sequences of operation and setpoints
 - d. Interlocks to packaged controls and other systems
 - e. Operator workstation graphics
 - f. Field sensor and panel locations
 - 3. The Commissioning Provider takes minutes at these meetings.

3.2 COMMISSIONING CHECKLISTS, START-UP, AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment and systems to be commissioned:
 - 1. Commissioning Checklists:
 - a. GC and Trade Subcontractors are to execute pre-functional system checks using the Commissioning Provider's created forms on the web based commissioning software Facility Grid.
 - b. The Commissioning Provider develops and completes the commissioning checklists and procedures for commissioned equipment and systems.
 - c. Calibrations: The construction checklists will contain requirements for calibrations when applicable. The Trade Subcontractors is responsible to calibrate all field-installed sensors and actuators using checkout documentation methods approved by the Commissioning Provider.

2. Manufacturer Installation and Startup Procedures:
 - a. A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:
 - 1) Flushing and cleaning of pipe.
 - 2) Filters, strainers, and screens.
 - 3) Valve positions.
 - 4) Pressure tests.
 - 5) Safeties.
 - 6) Manufacturer's tests.
 - b. The Trade Subcontractors shall complete the pre-start procedures in the manufacturer startup forms prior to starting equipment, including but not limited to verification of completion of wiring, safeties, lubrication, drive rotation and proper electrical test readings. Startup shall be conducted under supervision of responsible manufacturer representatives for major pieces of equipment. The GC shall notify the Commissioning Provider at least 5 days in advance of any equipment start-up, providing the Commissioning Provider a copy of the start-up plan at that time.
 - c. The Commissioning Provider shall observe startup and checkout of selected systems.
 - d. The Trade Subcontractors and manufacturer representatives shall execute start-up and provide the Commissioning Provider with a signed and dated copy of the completed start-up documentation. The Trade Subcontractors shall clearly note any items that have not been completed and the plan for their completion.
 - e. The Trade Subcontractors shall operate each commissioned device or system to the full extent of its capability, from minimum to maximum, under automatic and manual control and verify that the equipment, system and assembly is functioning according to the specifications, manufacturer recommendations and good operating practice.
 - f. The manufacturer startup reports and procedures for a given system shall be successfully completed and submitted prior to testing, adjusting and balancing of the equipment.
 - g. The Commissioning Provider will review startup documentation and identify incomplete areas.
 - h. The Trade Subcontractors shall correct all areas that are deficient or incomplete in the startup documentation in a timely manner.
3. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.3 FUNCTIONAL TESTING

- A. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Subcontractors. Functional tests for a given system shall not be conducted until they are fully operational under normal and reliable control with control calibrations, programming and control system graphics complete and checked out and the Trade

Subcontractors have submitted completed, applicable startup reports, satisfactory to the Commissioning Provider.

- B. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.
- C. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Subcontractors.
- D. Subcontractors shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.4 DEFICIENCIES AND NON-CONFORMANCE

A. Deficiency Management

- 1. The Commissioning Provider will record the results of document reviews, field observations, tests conducted or reviewed and trend logs or monitoring. All deficiencies will be recorded on a Deficiency Log kept by the Commissioning Provider. The Deficiency Log will be kept updated by the Commissioning Provider.
- 2. A current copy of the Deficiency Log will be provided to the GC and Owner/Owner Representative on a regular basis, as requested. New deficiencies will be identified.
- 3. Items that are incomplete or are requiring Designer input will be sent to the Designer and Owner/Owner Representative by the Commissioning Provider via appropriate channels.
- 4. When completion of a deficiency has been identified by the Commissioning Provider as holding up or is likely to delay any commissioning process, particularly functional testing, the GC, shall be required to notify the Commissioning Provider providing the planned actions and an expected date of completion. The GC shall notify the Commissioning Provider listing the actions taken to resolve the issue. It is not the responsibility of the Commissioning Provider to obtain this status information through meeting attendance, asking questions or field observation.
- 5. The Commissioning Provider documents resolutions in the Deficiency Log and schedules retesting and backchecking as needed.
- 6. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the Commissioning Provider will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so.
 - a. The time for the Commissioning Provider to direct, document and evaluate any retesting required because a specific construction checklist or start-up test item, reported to have been successfully completed, but determined during testing to be faulty, will be charged to the GC.
 - b. The GC shall reimburse the Commissioning Provider for costs when a scheduled test cannot be completed due to:

- 1) Failure of the GC to schedule the test with all parties required to perform the test or with regulatory authorities required to witness the test.
 - 2) Failure of the GC to provide required notice for tests that have been cancelled or rescheduled.
 - 3) Failure of the GC or Trade Subcontractors to have in place test equipment, support equipment, instrumentation, permits, or other ancillary equipment or systems required for successful execution of the test.
 - 4) Failure of the Trade Subcontractors to complete pre-start or start-up procedures or other work required as a prerequisite for execution of the test.
7. The GC shall respond in writing to the Commissioning Provider at least as often as commissioning meetings are being scheduled concerning the status of each outstanding deficiency identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
- B. Approval and Acceptance: The Commissioning Provider will note each satisfactorily demonstrated function on the test form. Functional testing or acceptance of a system is indicated after all testing and monitoring is complete and there are no outstanding deficiencies for that equipment or system in the Commissioning Provider's Deficiency Log.

3.5 DEFERRED TESTING

- A. Unforeseen Deferred Tests: If any functional test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of functional testing may be delayed.
- B. Seasonal Testing: During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) specified in the testing requirements shall be completed as part of this contract. The Commissioning Provider will coordinate this activity. Tests will be executed, documented and deficiencies corrected by the Trade Subcontractors, with facilities staff and the Commissioning Provider witnessing. The Trade Subcontractors shall make needed final adjustments to the O&M manuals and record documents due to the testing results.

3.6 ADDITIONAL DOCUMENTATION

- A. Documentation required of the Trade Subcontractors shall consist of the following:
 1. Startup and initial checkout forms completed.
 2. Record of deficiencies and incomplete items for tests they are responsible to document.
 3. Training record.
- B. O&M Documentation Completion and Review:
 1. Prior to substantial completion, the Commissioning Provider shall review the O&M manuals for systems that were commissioned to verify compliance with the specifications. The Commissioning Provider will communicate deficiencies in the manuals to the Commissioning Team.

2. The Commissioning Provider will also review each equipment warranty and verify that requirements to keep the warranty valid are clearly stated.
3. This work does not supersede the Design Team's review of the O&M manuals.

3.7 TRAINING OF FACILITY PERSONNEL

- A. The Trade Subcontractors are responsible to provide training for facility personnel per the Contract Documents. The Trade Subcontractors shall work with the Commissioning Provider to develop appropriate training and orientation agendas for equipment and systems and provide skilled trainers for the sessions. The Commissioning Provider will verify that the Trade Subcontractors execute training per the Contract Documents.

END OF SECTION 220800

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Copper tube and fittings.
2. PEX tube and fittings.
3. Piping joining materials.
4. Encasement for piping.
5. Transition fittings.
6. Dielectric fittings.

1.3 ACTION SUBMITTALS

- A. Product Data: For transition fittings and dielectric fittings.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 FIELD CONDITIONS

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
- B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper.
- C. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- D. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- E. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
- F. Copper Unions:
 - 1. MSS SP-123.
 - 2. Cast-copper-alloy, hexagonal-stock body.
 - 3. Ball-and-socket, metal-to-metal seating surfaces.
 - 4. Solder-joint or threaded ends.

2.3 PIPING JOINING MATERIALS

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

2.4 TRANSITION FITTINGS

- A. General Requirements:

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

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

2.5 DIELECTRIC FITTINGS

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

- B. Dielectric Unions:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Jomar Valve.
 - c. WATTS.
2. Standard: ASSE 1079.
3. Pressure Rating: 150 psig.
4. End Connections: Solder-joint copper alloy and threaded ferrous.

- C. Dielectric Flanges:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. WATTS.
2. Standard: ASSE 1079.
3. Factory-fabricated, bolted, companion-flange assembly.
4. Pressure Rating: 150 psig.
5. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

- D. Dielectric-Flange Insulating 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. Nonconducting materials for field assembly of companion flanges.
3. Pressure Rating: 150 psig.
4. Gasket: Neoprene or phenolic.
5. Bolt Sleeves: Phenolic or polyethylene.
6. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Grinnell Mechanical Products.
 - b. Matco-Norca.
 - c. Precision Plumbing Products.
2. Standard: IAPMO PS 66.
3. Electroplated steel nipple complying with ASTM F 1545.
4. Pressure Rating and Temperature: 300 psig at 225 deg F.
5. End Connections: Male threaded or grooved.
6. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105/A21.5.
- 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. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping" and with requirements for drain valves and strainers in Section 221119 "Domestic Water Piping Specialties."
- E. Install shutoff valve immediately upstream of each dielectric fitting.

- F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements for pressure-reducing valves in Section 221119 "Domestic Water Piping Specialties."
- G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- H. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.
- J. 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.
- K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- L. Install piping to permit valve servicing.
- M. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than the system pressure rating used in applications below unless otherwise indicated.
- N. Install piping free of sags and bends.
- O. Install fittings for changes in direction and branch connections.
- P. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- Q. Install pressure gages on suction and discharge piping for each plumbing pump and packaged booster pump. Comply with requirements for pressure gages in Section 220519 "Meters and Gages for Plumbing Piping."
- R. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."
- S. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements for thermometers in Section 220519 "Meters and Gages for Plumbing Piping."
- T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.
- C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints for Copper Tubing: Comply with CDA's "Copper Tube Handbook," "Braze Joints" chapter.
- E. Soldered Joints for Copper Tubing: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. 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.
- G. Joints for Dissimilar-Material Piping: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

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

3.5 DIELECTRIC FITTING INSTALLATION

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

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for seismic-restraint devices in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- B. Comply with requirements for pipe hanger, support products, and installation in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- 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 5: 10 feet with 1/2-inch rod.
 - 6. NPS 6: 10 feet with 5/8-inch rod.
 - 7. NPS 8: 10 feet with 3/4-inch rod.
- F. Install supports for vertical copper tubing every 10 feet.
- G. Support piping and tubing not listed in this article according to MSS SP-58 and manufacturer's written instructions.

3.7 CONNECTIONS

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

- D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:
1. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 2. Plumbing Fixtures: Cold- and hot-water-supply piping in sizes indicated, but not smaller than that required by plumbing code.
 3. Equipment: Cold- and hot-water-supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.8 IDENTIFICATION

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

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Piping Inspections:
 - a. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - b. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - 1) Roughing-in Inspection: Arrange for inspection of piping before concealing or closing in after roughing in and before setting fixtures.
 - 2) Final Inspection: Arrange for authorities having jurisdiction to observe tests specified in "Piping Tests" Subparagraph below and to ensure compliance with requirements.
 - c. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - d. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
 2. Piping Tests:
 - a. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - b. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.

- c. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - d. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow it to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - e. Repair leaks and defects with new materials, and retest piping or portion thereof until satisfactory results are obtained.
 - f. Prepare reports for tests and for corrective action required.
- B. Domestic water piping will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.10 ADJUSTING

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

3.11 CLEANING

- A. Clean and disinfect potable domestic water piping as follows:
 - 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 - 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:

- 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Repeat procedures if biological examination shows contamination.
 - e. Submit water samples in sterile bottles to authorities having jurisdiction.
- B. Clean non-potable domestic water piping as follows:
1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- C. Prepare and submit reports of purging and disinfecting activities. Include copies of water-sample approvals from authorities having jurisdiction.
- D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.12 PIPING SCHEDULE

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.
- C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.
- D. Under-building-slab, domestic water, building-service piping, NPS 3 and smaller, shall be the following:
1. Soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
- E. Under-building-slab, domestic water piping, NPS 2 and smaller, shall be the following:
1. soft copper tube, ASTM B 88, Type K; wrought-copper, solder-joint fittings; and brazed joints.
- F. Aboveground exposed domestic water piping, NPS 2 and smaller, shall be the following:

1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
- G. Aboveground concealed domestic water piping, NPS 2 and smaller, shall be one of the following:
1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and soldered joints.
- H. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be the following:
1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); cast- or wrought-copper, solder-joint fittings; and soldered joints.

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 ball or gate valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
 2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use ball valves with flanged ends for piping NPS 2-1/2 and larger.
 3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

END OF SECTION 221116

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Vacuum breakers.
2. Backflow preventers.
3. Water pressure-reducing valves.
4. Balancing valves.
5. Temperature-actuated, water mixing valves.
6. Strainers.
7. Outlet boxes.
8. Hose bibbs.
9. Wall hydrants.
10. Post hydrants.
11. Drain valves.
12. Water-hammer arresters.
13. Air vents.
14. Trap-seal primer valves.
15. Trap-seal primer systems.
16. Water meters.

- B. Related Requirements:

1. Section 220519 "Meters and Gauges for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Section 221116 "Domestic Water Piping" for water meters.
3. Section 224500 "Emergency Plumbing Fixtures" for water tempering equipment.
4. Section 224713 "Drinking Fountains" for water filters for water coolers.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 and NSF 14.
- B. Comply with NSF 372 for low lead.

2.2 PERFORMANCE REQUIREMENTS

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

2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ames. Co.
 - b. Cash ACME.
 - c. Conbraco Industries, Inc.
 - d. FEBCO; SPX Valves & Controls.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Plumbing Products Group; Wilkins Div.
 - 2. Standard: ASSE 1001.
 - 3. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Rough bronze or Chrome plated.
- B. Hose-Connection Vacuum Breakers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. MIFAB, Inc.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Woodford Manufacturing Company.
 - d. Zurn Plumbing Products Group; Light Commercial Operation.
 - e. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1011.
3. Body: Bronze, nonremovable, with manual drain.
4. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
5. Finish: Chrome or nickel plated or Rough bronze.

2.4 BACKFLOW PREVENTERS

A. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. FEBCO; SPX Valves & Controls.
 - c. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 (83) psig (kPa) maximum, through middle third of flow range.
5. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved or steel with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
6. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
7. Configuration: Designed for horizontal, straight-through flow.
8. Accessories:
 - a. Valves NPS 2 (DN 50) and Smaller: Ball type with threaded ends on inlet and outlet.
 - b. Valves NPS 2-1/2 (DN 65) and Larger: Outside-screw and yoke-gate type with flanged ends on inlet and outlet.
 - c. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

2.5 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ITT Industries; Bell & Gossett Div.

b. NIBCO, Inc.

2. Type: Ball valve with two readout ports and memory-setting indicator.
3. Body: Brass.
4. Size: Same as connected piping, but not larger than NPS 2 (DN 50).
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.
6. Valve shall be certified lead-free.

2.6 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. Lawler Manufacturing Company, Inc.
 - b. Leonard Valve Company.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
4. Type: Exposed-mounted, 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, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Finish: Chrome plated or Polished, chrome plated.
9. Piping Finish: Chrome plated or Copper.
10. Cabinet: Factory fabricated, stainless steel, for surface mounting and with hinged, stainless-steel door.

B. Individual-Fixture, Water Tempering Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Honeywell Water Controls.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company.
 - d. Powers; a Watts Industries Co.
 - e. Watts Industries, Inc.; Water Products Div.
 - f. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1016, thermostatically controlled, water tempering valve.
3. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
4. Body: Bronze body with corrosion-resistant interior components.
5. Temperature Control: Adjustable.
6. Inlets and Outlet: Threaded.
7. Finish: Rough or chrome-plated bronze.

2.7 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig (860 kPa) minimum unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved, epoxy coated and for NPS 2-1/2 (DN 65) and larger.
3. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
4. Screen: Stainless steel with round perforations unless otherwise indicated.
5. Perforation Size:
 - a. Strainers NPS 2 (DN 50) and Smaller: 0.062 (1.57) inch (mm).
 - b. Strainers NPS 2-1/2 to NPS 4 (DN 65 to DN 100): 0.062 (1.57) inch (mm).
6. Drain: Pipe plug.

2.8 OUTLET BOXES

A. 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. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Light Commercial Operation.
2. Mounting: Recessed.
3. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.
4. Faucet: Combination valved fitting or 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 (DN 15) gate, globe, or ball valves and NPS 1/2 (DN 15) copper, water tubing.
6. Drain: NPS 2 (DN 50) standpipe and P-trap for direct waste connection to drainage piping.
7. Inlet Hoses: Two 60-inch- (1500-mm-) long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
8. Drain Hose: One 48-inch- (1200-mm-) long, rubber household clothes washer drain hose with hooked end.
9. Provide with integral water hammer arrestor.

B. Ice Maker 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. Watts Industries, Inc.; Water Products Div.
 - d. Zurn Plumbing Products Group; Light Commercial Operation.
2. Mounting: Recessed.
 3. Material and Finish: Enameled-steel, epoxy-painted-steel, or plastic box and faceplate.
 4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 (DN 15) or smaller copper tube outlet.
 5. Supply Shutoff Fitting: NPS 1/2 (DN 15) gate, globe, or ball valve and NPS 1/2 (DN 15) copper, water tubing.

2.9 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Woodford Manufacturing Company.
 - b. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
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(s): Two with each wall hydrant.

B. Nonfreeze, Hot- and Cold-Water Wall Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Woodford Manufacturing Company.
 - b. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig (860 kPa).
4. Operation: Loose key.

5. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed.
8. Box: Deep, flush mounted with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Vacuum Breaker:
 - a. Nonremovable, manual-drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.
 - b. Garden-hose thread complying with ASME B1.20.7 on outlet.
11. Operating Key(s): Two with each wall hydrant.

2.10 POST HYDRANTS

A. Nonfreeze, Nondraining-Type Post Hydrants:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Woodford Manufacturing Company.
 - b. Zurn Plumbing Products Group; Wilkins Div.
2. Operation: Lever-piston operating mechanism and nondraining water-storage reservoir, designed without drain.
3. Length: As required for burial of valve below frost line.
4. Inlet: NPS 1 (DN 25) threaded.
5. Outlet:
 - a. NPS 1 (DN 25) outlet and coupling plug for 1-inch (25-mm) hose.
 - b. NPS 1 by NPS 3/4 (DN 25 by DN 20) adapter with nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
 - c. Garden-hose thread complying with ASME B1.20.7 on outlet.
 - d. NPS 1 by NPS 3/4 (DN 25 by DN 20) adapter with nonremovable, drainable, hose-connection backflow preventer complying with ASSE 1052.
 - e. Garden-hose thread complying with ASME B1.20.7 on outlet.

2.11 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 (2760-kPa) minimum CWP.
3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
6. Seats and Seals: Replaceable.

7. Handle: Vinyl-covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

2.12 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

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

2.13 TRAP-SEAL PRIMER DEVICE

A. Drainage-Type, Trap-Seal Primer Device:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. PPP Inc.
 - b. Sioux Chief Manufacturing Company, Inc.
2. Standard: ASSE 1044, lavatory P-trap with NPS 3/8 (DN 10) minimum, trap makeup connection.
3. Size: NPS 1-1/4 (DN 32) minimum.
4. Material: Chrome-plated, cast brass.

2.14 TRAP-SEAL PRIMER SYSTEMS

A. Trap-Seal Primer Systems:

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

- a. PPP Inc.
- b. Sioux Chief Manufacturing Company, Inc.
2. Standard: ASSE 1044.
3. Piping: NPS 3/4, ASTM B 88, Type L (DN 20, ASTM B 88M, Type B); copper, water tubing.
4. Cabinet: Recessed or Surface-mounted steel box with stainless-steel cover.
5. Electric Controls: 24-hour timer, solenoid valve, and manual switch for 120-V ac power.
 - 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.
6. Vacuum Breaker: ASSE 1001.
7. Number Outlets: As shown on drawings, with additional outlet for spare capacity.
8. Size Outlets: NPS 1/2 (DN 15).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Backflow Preventers: 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 unacceptable for this application.
 3. Do not install bypass piping around backflow preventers.
- B. Water Regulators: Install with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.
- C. Water Control Valves: Install with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.
- D. Automatic Water Shutoff Valves: Test for signal strength before valve installation. Install automatic shutoff valve downstream from main domestic water shutoff valve and downstream from fire sprinkler system supply. Install valve controller in an accessible location with sensors in areas where water is likely to accumulate.
- E. Balancing Valves: Install in locations where they can easily be adjusted.
- F. Temperature-Actuated, Water Mixing Valves: Install with check stops or shutoff valves on inlets and with shutoff valve on outlet. Install mixing valve per manufacturer's requirements, and right side up.

1. Install cabinet-type units recessed in or surface mounted on wall as specified.
- G. Y-Pattern Strainers: For water, install on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
- H. Hose Stations: Install with check stops or shutoff valves on inlets and with thermometer on outlet.
 1. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking, wall reinforcement between studs. Comply with requirements for fire-retardant-treated-wood blocking in Section 061053 "Miscellaneous Rough Carpentry."
- I. Nonfreeze, Nondraining-Type Post Hydrants: Set in concrete or pavement.
- J. Water-Hammer Arresters: Install in water piping according to PDI-WH 201. Install water hammer arrestors for fixtures with quick closing valves such as washing machine, and water closets.
- K. Air Vents: Install vents at high points of water piping. Install drain piping and discharge onto floor drain.
- L. Drainage-Type, Trap-Seal Primer Device: Install as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.
- M. Trap-Seal Primer Systems: Install with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust system for proper flow.

3.2 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. When installing piping specialties adjacent to equipment and machines, allow space for service and maintenance.
- C. Comply with requirements for grounding equipment in Section 260526 "Grounding and Bonding for Electrical Systems."

3.3 IDENTIFICATION

- A. Plastic Labels for Equipment: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 1. Pressure vacuum breakers.
 2. Intermediate atmospheric-vent backflow preventers.
 3. Reduced-pressure-principle backflow preventers.

4. Water pressure-reducing valves.
5. Calibrated balancing valves.
6. Primary, thermostatic, water mixing valves.
7. Primary water tempering valves.
8. Outlet boxes.
9. Hose stations.
10. Supply-type, trap-seal primer valves.
11. Trap-seal primer systems.

- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

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

3.5 ADJUSTING

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

END OF SECTION 221119

SECTION 221123.21 - INLINE, DOMESTIC-WATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. In-line, sealless centrifugal pumps.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Detail pumps and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members to which pumps will be attached.
 - 2. Size and location of initial access modules for acoustical tile.
- B. Seismic Qualification Data: Certificates, for inline, domestic-water pumps, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. UL Compliance: UL 778 for motor-operated water pumps.
- C. Drinking Water System Components - Health Effects and Drinking Water System Components - Lead Content Compliance: NSF 61 and NSF 372.
- D. Seismic Performance: Inline, domestic-water pumps 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."
 - 2. Component Importance Factor: 1.0.
 - 3. See S0.1.

2.2 IN-LINE, SEALLESS CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, in-line, close-coupled, canned-motor, sealless, overhung-impeller centrifugal pumps.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Bell and Gossett Domestic Pump; ITT Industries.
 - 2. Grundfos Pumps Corp.
- C. Capacities and Characteristics:
 - 1. See Drawings.

D. Pump Construction:

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge type with motor and impeller on common shaft and designed for installation with pump and motor shaft horizontal.
2. Minimum Working Pressure: 125 psig (860 kPa).
3. Maximum Continuous Operating Temperature: 220 deg F (104 deg C).
4. Casing: Bronze, with threaded or companion-flange connections.
5. Impeller: composite or stainless steel.
6. Motor: Single speed.

2.3 MOTORS

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

2.4 CONTROLS

- A. As indicated on drawings and sequence of operations.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Mount pumps in orientation complying with manufacturer's written instructions.
- C. Pump Mounting:
1. As indicated on Structural and Plumbing Drawings.
- D. Install thermostats in hot-water return piping.

3.3 PIPING CONNECTIONS

- A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to inline, domestic-water pumps, allow space for service and maintenance.
- C. Connect domestic-water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles.
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Horizontally mounted, in-line, separately coupled centrifugal pumps.
 - b. Horizontally mounted, in-line, close-coupled centrifugal pumps.
 - c. Vertically mounted, in-line, close-coupled centrifugal pumps.
 - d. Comply with requirements for flexible connectors specified in Section 221116 "Domestic Water Piping."
- D. Install shutoff valve and strainer on suction side of each pump, and check, shutoff, and throttling valves on discharge side of each pump. Install valves same size as connected piping. Comply with requirements for strainers specified in Section 221119 "Domestic Water Piping Specialties." Comply with requirements for valves specified in the following:
 - 1. Section 220523.12 "Ball Valves for Plumbing Piping."
 - 2. Section 220523.14 "Check Valves for Plumbing Piping."
 - 3. Install pressure gauge and snubber at suction of each pump and pressure gauge and snubber at discharge of each pump. Install at integral pressure-gauge tappings where provided or install pressure-gauge connectors in suction and discharge piping around pumps. Comply with requirements for pressure gauges and snubbers specified in Section 220519 "Meters and Gages for Plumbing Piping."

3.4 CONTROL CONNECTIONS

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

3.5 IDENTIFICATION

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

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
- E. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- F. Inline, domestic-water pump will be considered defective if it does not pass tests and inspections.
- G. 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.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Set pressure switches, thermostats, timers, and time-delay relays 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. Adjust timer settings.

3.8 ADJUSTING

- A. Adjust inline, 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 221123.21

SECTION 221316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless, cast-iron soil pipe and fittings.
3. Galvanized-steel pipe and fittings.
4. Copper tube and fittings.
5. PP pipe and fittings.
6. Encasement for underground metal piping.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For hubless, single-stack drainage system. Include plans, elevations, sections, and details.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For waste and vent piping, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Detailed description of piping anchorage devices on which the certification is based and their installation requirements.
- B. Field quality-control reports.

1.5 FIELD CONDITIONS

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

1. Notify Architect no fewer than two days in advance of proposed interruption of sanitary waste service.
2. Do not proceed with interruption of sanitary waste service without Architect's written permission.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:
 1. Soil, Waste, and Vent Piping: 10-foot head of water.
- B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

2.2 PIPING MATERIALS

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Heavy-Duty, Hubless-Piping Couplings:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ANACO-Husky.
 - b. Clamp-All Corp.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 2. Standards: ASTM C 1277 and ASTM C 1540.
 3. Description: Stainless-steel shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.4 GALVANIZED-STEEL PIPE AND FITTINGS

- A. Galvanized-Steel Pipe: ASTM A 53/A 53M, Type E, Schedule 40 class. Include square-cut-grooved or threaded ends matching joining method.
- B. Galvanized-Cast-Iron Drainage Fittings: ASME B16.12, threaded.
- C. Steel Pipe Pressure Fittings:
 - 1. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Schedule 40, seamless steel pipe. Include ends matching joining method.
 - 2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - 3. Galvanized-Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, standard pattern.

2.5 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.
- B. Copper Pressure Fittings:
 - 1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

2.6 POLYPROPYLENE DRAINAGE PIPE AND FITTINGS

- A. PP Drainage Pipe and Fittings: ASTM F1412 pipe extruded and drainage-pattern fittings molded, with Schedule 40 dimensions and with fire-retardant additive complying with ASTM D4101; with fusion-joint ends.
 - 1. Exception: Pipe and fittings made from PP resin without fire-retardant additive may be used for underground installation.
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Georg Fischer Inc.
 - b. IPEX USA LLC.
 - c. Orion Fittings; A WATTS Brand.

2.7 SPECIALTY PIPE FITTINGS

- A. Transition Couplings:
 - 1. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
 - 2. Unshielded, Nonpressure Transition Couplings:

- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Dallas Specialty & Mfg. Co.
 - 2) Fernco Inc.
 - 3) Mission Rubber Company, LLC; a division of MCP Industries.
 - 4) Plastic Oddities.
 - b. Standard: ASTM C 1173.
 - c. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. End Connections: Same size as and compatible with pipes to be joined.
 - e. Sleeve Materials:
 - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - 2) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
3. Shielded, Nonpressure Transition Couplings:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Cascade Waterworks Mfg. Co.
 - 2) Mission Rubber Company, LLC; a division of MCP Industries.
 - b. Standard: ASTM C 1460.
 - c. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - d. End Connections: Same size as and compatible with pipes to be joined.
- B. Dielectric Fittings:
1. Dielectric Unions:
- a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Capitol Manufacturing Company.
 - 2) Central Plastics Company.
 - 3) HART Industrial Unions, LLC.
 - 4) Jomar Valve.
 - 5) Matco-Norca.
 - 6) WATTS.
 - 7) Wilkins.
 - b. Description:

- 1) Standard: ASSE 1079.
 - 2) Pressure Rating: 125 psig minimum at 180 deg F.
 - 3) End Connections: Solder-joint copper alloy and threaded ferrous.
2. Dielectric Flanges:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Capitol Manufacturing Company.
 - 2) Central Plastics Company.
 - 3) Matco-Norca.
 - 4) WATTS.
 - 5) Wilkins.
 - b. Description:
 - 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.
3. Dielectric-Flange Insulating Kits:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Advance Products & Systems, Inc.
 - 2) Calpico, Inc.
 - 3) Central Plastics Company.
 - 4) Pipeline Seal and Insulator, Inc.
 - b. Description:
 - 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.
4. Dielectric Nipples:
 - a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Elster Perfection Corporation.
 - 2) Grinnell Mechanical Products.
 - 3) Matco-Norca.
 - 4) Precision Plumbing Products.

5) Victaulic Company.

b. Description:

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

2.8 ENCASEMENT FOR UNDERGROUND METAL PIPING

- A. Standard: ASTM A 674 or AWWA C105/A 21.5.
- B. Material: Linear low-density polyethylene film of 0.008-inch or high-density, cross-laminated polyethylene film of 0.004-inch minimum thickness.
- C. Form: Sheet or tube.
- D. Color: Black or natural.

PART 3 - EXECUTION

3.1 EARTH MOVING

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

3.2 PIPING INSTALLATION

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

- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- K. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends.
 - 1. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical.
 - 2. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe.
 - a. Straight tees, elbows, and crosses may be used on vent lines.
 - 3. Do not change direction of flow more than 90 degrees.
 - 4. Use proper size of standard increasers and reducers if pipes of different sizes are connected.
 - a. Reducing size of waste piping in direction of flow is prohibited.
- L. Lay buried building waste piping beginning at low point of each system.
 - 1. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream.
 - 2. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
 - 3. Maintain swab in piping and pull past each joint as completed.
- M. Install soil and waste and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Sanitary Waste: 2 percent downward in direction of flow for piping NPS 3 and smaller; 2 percent downward in direction of flow for piping NPS 4 and larger.
 - 2. Horizontal Sanitary Waste Piping: 2 percent downward in direction of flow.
 - 3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- N. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105/A 21.5.
- O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- P. Install sleeves for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for sleeves specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs.
 1. Comply with requirements for sleeve seals specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors.
 1. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."

3.3 JOINT CONSTRUCTION

- A. Join hubless, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-piping coupling joints.
- B. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1.
 1. Cut threads full and clean using sharp dies.
 2. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
 - c. Do not use pipe sections that have cracked or open welds.
- C. Chemical-Waste Sewerage Outside the Building:
 1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints according to ASTM F1290.
- D. Chemical-Waste Piping Inside the Building:
 1. Plastic-Piping Fusion Joints: Make PP drainage-piping joints according to ASTM F1290.
- E. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

3.4 SPECIALTY PIPE FITTING INSTALLATION

A. Transition Couplings:

1. Install transition couplings at joints of piping with small differences in ODs.
2. In Waste Drainage Piping: Unshielded or Shielded, nonpressure transition couplings.

B. Dielectric Fittings:

1. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
2. Dielectric Fittings for NPS 2 and Smaller: Use dielectric nipples or unions.
3. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits or nipples.

3.5 HANGER AND SUPPORT INSTALLATION

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

1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
3. Vertical Piping: MSS Type 8 or Type 42, clamps.
4. Install individual, straight, horizontal piping runs:
 - a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
 - c. Longer Than 100 Feet if Indicated: MSS Type 49, spring cushion rolls.
5. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
6. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Install hangers for cast-iron steel and copper soil piping, with maximum horizontal spacing and minimum rod diameters, to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

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

D. Support vertical runs of cast iron steel and copper soil piping to comply with MSS-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect waste and vent piping to the following:

1. Plumbing Fixtures: Connect waste piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect waste and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Install test tees (wall cleanouts) in conductors near floor and floor cleanouts with cover flush with floor.
5. Comply with requirements for cleanouts and drains specified in Section 221319 "Sanitary Waste Piping Specialties."
6. Equipment: Connect waste piping as indicated.
 - a. Provide shutoff valve if indicated and union for each connection.
 - b. Use flanges instead of unions for connections NPS 2-1/2 and larger.

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

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

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

F. Connect force-main piping to the following:

1. Sanitary Sewer: To exterior force main.
2. 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 220553 "Identification for Plumbing Piping and Equipment."

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in 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.

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. 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 and waste piping NPS 4 and smaller shall be the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- C. Aboveground, vent piping NPS 4 and smaller shall be the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- D. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- E. Underground/Aboveground, grease-waste, and grease-vent piping NPS 4 and smaller shall be any of the following:
 - 1. Hubless, cast-iron soil pipe and fittings; heavy-duty cast-iron hubless-piping couplings; and coupled joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, nonpressure transition couplings.
- F. Aboveground Chemical-Waste Piping (AW): Use the following piping materials for each size range:
 - 1. NPS 1-1/2 to NPS 6: PP drainage piping and fusion joints.
- G. Under Slab-on-Grade, Indoor, Chemical-Waste Piping (AW): Use the following piping materials for each size range:
 - 1. NPS 1-1/2 to NPS 6: PP drainage piping and fusion joints.
- H. Aboveground sanitary-sewage force mains NPS 1-1/2 and NPS 2 shall be any of the following:
 - 1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
 - 2. Galvanized-steel pipe, pressure fittings, and threaded joints.
- I. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 shall be the following:

1. Hard copper tube, Type L; copper pressure fittings; and soldered joints.
2. Galvanized-steel pipe, pressure fittings, and threaded joints.
3. Grooved-end, galvanized-steel pipe; grooved-joint, galvanized-steel-pipe appurtenances; and grooved joints.

J. Underground sanitary-sewage force mains NPS 4 and smaller shall be the following:

1. Hard copper tube, Type L; wrought-copper pressure fittings; and soldered joints.
2. Fitting-type transition coupling for piping smaller than NPS 1-1/2 and pressure transition coupling for NPS 1-1/2 and larger if dissimilar pipe materials.

END OF SECTION 221316

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Cleanouts.
 - 2. Roof flashing assemblies.
 - 3. Miscellaneous sanitary drainage piping specialties.

- B. Related Requirements:

- 1. Section 221423 "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. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. FOG disposal systems.
- B. Shop Drawings:
 - 1. Show fabrication and installation details for frost-resistant vent terminals.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: For FOG disposal systems, 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.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sanitary waste piping specialties to include in emergency, operation, and maintenance manuals.

1.7 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. Cultures: Provide 1-gal. (3.8-L) bottles of bacteria culture recommended by manufacturer of FOG disposal systems equal to 200 percent of amount installed, but no fewer than 2 1-gal. (3.8-L) bottles.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTIONS

- A. Sanitary waste piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14 for plastic sanitary waste piping specialty components.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing, and marked for intended location and application.

2.2 CLEANOUTS

- A. Cast-Iron Exposed Cleanouts:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. WATTS.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure: Countersunk, plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Tyler Pipe; a subsidiary of McWane Inc.
 - d. WATTS.
 - e. Zurn Industries, LLC.
2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Inside calk.
8. Closure: Brass plug with straight threads and gasket.
9. Adjustable Housing Material: Cast iron with threads.
10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

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 A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
5. Closure Plug:
 - a. Cast iron.
 - b. Countersunk head.
 - c. Drilled and threaded for cover attachment screw.
 - d. Size: Same as or not more than one size smaller than cleanout size.
6. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
7. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.3 ROOF FLASHING ASSEMBLIES

A. Roof Flashing Assemblies:

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

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

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

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

B. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.

5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 2. Locate at each change in direction of piping greater than 45 degrees.
 3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
 4. Locate at base of each vertical soil and waste stack.
- B. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- C. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- D. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."
- E. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."
- F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 2. Size: Same as floor drain inlet.
- G. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- H. Install sleeve and sleeve seals with each riser and stack passing through floors with waterproof membrane.
- I. Install vent caps on each vent pipe passing through roof.
- J. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- K. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch (25-mm) clearance between vent pipe and roof substrate.

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

3.2 CONNECTIONS

- A. Comply with requirements in Section 221316 "Sanitary Waste and Vent Piping" for piping installation requirements. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FLASHING INSTALLATION

- A. Comply with requirements in Section 076200 "Sheet Metal Flashing and Trim."
- B. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required.
- C. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.
- D. Set flashing on floors and roofs in solid coating of bituminous cement.
- E. Secure flashing into sleeve and specialty clamping ring or device.
- F. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Section 076200 "Sheet Metal Flashing and Trim."
- G. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

3.4 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.
 - 1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections, and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled FOG disposal systems and their installation, including piping and electrical connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

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

END OF SECTION 221319

SECTION 221319.13 - SANITARY DRAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Floor drains.
- 2. Floor sinks.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

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

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. 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. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3.
3. Pattern: Floor and Funnel floor (See drawings.) drain.
4. Body Material: Gray iron.
5. Seepage Flange: Required.
6. Clamping Device: Required.
7. Outlet: Bottom.
8. Backwater Valve: Not required.
9. Coating on Interior and Exposed Exterior Surfaces: Not required.
10. Sediment Bucket: Not required.
11. Top or Strainer Material: Bronze.
12. Top Shape: Round.
13. Top Loading Classification: Heavy Duty.
14. Funnel: Required at certain locations, see drawings.

2.3 FLOOR SINKS

A. Cast-Iron Floor Sinks:

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. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.7.
3. Pattern: Floor drain.
4. Body Material: Cast iron.
5. Anchor Flange: Required.
6. Clamping Device: Not required.
7. Outlet: Bottom, no-hub connection.
8. Coating on Interior Surfaces: Not required.
9. Sediment Bucket: Not required.
10. Internal Strainer: Dome.

11. Internal Strainer Material: Aluminum.
12. Top Grate Material: Cast iron, loose.
13. Top of Body and Grate Finish: Nickel bronze.
14. Top Shape: Square.
15. Funnel: Not required.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 1. Position floor drains for easy access and maintenance.
 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
 3. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
 4. Install floor-drain flashing collar or flange, so no leakage occurs between drain and adjoining flooring.
 - a. Maintain integrity of waterproof membranes where penetrated.
 5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- B. Install trench drains at low points of surface areas to be drained.
 1. Set grates of drains flush with finished surface, unless otherwise indicated.
- C. Comply with ASME A112.3.1 for installation of stainless-steel channel drainage systems.
 1. Install on support devices, so that top will be flush with adjacent surface.

3.2 CONNECTIONS

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

- C. Comply with requirements in Section 221323 "Sanitary Waste Interceptors" for grease interceptors, grease-removal devices, oil interceptors, sand interceptors, and solid interceptors.
- D. Install piping adjacent to equipment to allow service and maintenance.
- E. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 LABELING AND IDENTIFYING

- A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.4 PROTECTION

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

END OF SECTION 221319.13

SECTION 221323 - SANITARY WASTE INTERCEPTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Grease interceptors.
2. Garbage Disposers
3. Solids Interceptors

1.3 DEFINITIONS

- A. FRP: Fiberglass-reinforced plastic.
- B. PP: Polypropylene plastic.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of concrete interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.
- B. Shop Drawings: For each type and size of precast-concrete interceptor indicated.
 1. Include materials of construction, dimensions, rated capacities, retention capacities, location and size of each pipe connection, furnished specialties, and accessories.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Interceptors, 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. Interceptors.
 2. Piping connections. Include size, location, and elevation of each.
 3. Interface with underground structures and utility services.

1.6 PROJECT CONDITIONS

- A. Interruption of Existing Sewer Services: Do not interrupt services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sewer services according to requirements indicated:
1. Notify Architect and Owner no fewer than seven days in advance of proposed interruption of service.
 2. Do not proceed with interruption of sewer services without Architect's and Owner's written permission.

PART 2 - PRODUCTS

2.1 GREASE INTERCEPTORS

- A. Grease Interceptors, GI-1:
1. Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Josam Company.
 - b. Schier Products Company.
 - c. Smith, Jay R. Mfg. Co.
 - d. Watts Drainage Products.
 - e. Zurn Plumbing Products Group.
 - f. Wilbert Precast, Inc.
 2. Include rubber-gasketed joints, vent connections, manholes, compartments or baffles, and piping or openings to retain grease and to permit wastewater flow.
 3. Structural Design Loads:
 - a. Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
 4. Resilient Pipe Connectors: ASTM C 923, cast or fitted into interceptor walls, for each pipe connection.
 5. Steps: ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, 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 interceptor to finished grade is less than 60 inches.
 6. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover.
 7. 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.
 - a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
 - b. Gray Iron: ASTM A 48, Class 35, unless otherwise indicated.

- c. Include indented top design with lettering cast into cover, using wording equivalent to "GREASE INTERCEPTOR."
- 8. Capacities and Characteristics: As indicated.
- B. Accessories:
 - 1. 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.
 - a. Ductile Iron: ASTM A 536, Grade 60-40-18, unless otherwise indicated.
 - b. Include indented top design with lettering cast into cover, using wording equivalent to "GSHP MANIFOLD".
 - c. Capacities and Characteristics: As indicated.
 - 2. Precast-Concrete Manhole Risers: ASTM C 478, with rubber-gasket joints.
 - a. Structural Design Loads:
 - 1) Heavy-Traffic Load: Comply with ASTM C 890, A-16 (ASSHTO HS20-44).
 - b. Length: From top of underground concrete structure to grade.
 - c. Riser Sections: 3-inch minimum thickness and 36-inch diameter.
 - d. Top Section: Eccentric cone, unless otherwise indicated. Include top of cone to match grade ring size.
 - e. Gaskets: ASTM C 443, rubber.
 - 3. Steps: 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 one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch intervals.

2.2 GARBAGE DISPOSER

A. Garbage Disposer, GD-1

- 1. Manufacturers: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - a. Josam Company.
 - b. MIFAB, Inc.
 - c. Smith, Jay R. Mfg. Co.
 - d. Watts Drainage Products.
 - e. Insinkerator Foodservice
- 2. Type: Compact residential disposer made for removing foodwaste from waste water.
- 3. Grind Chamber: Corrosion Resistant Stainless Steel
- 4. Finish: Waterborne enamel

5. Shredding Elements: Stationary and rotating; galvanized steel
6. Motor: 1/2 HP induction motor
7. Body Dimensions: 7"x7"x13
8. Capacity: 26 oz

2.3 ACID NEUTRALIZATION TANKS

A. Acid Neutralization Tanks:

1. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Josam Company.
 - b. Schier Products Company.
 - c. Smith, Jay R. Mfg. Co.
 - d. Watts Drainage Products.
 - e. Zurn Plumbing Products Group.
2. Type: Factory-fabricated tank for separating and neutralizing acid in wastewater.
3. Include inlets, outlets, vents, cover, riser system, monitoring equipment
4. Cover: Pedestrian-rated 2,000 lb capacity; water/gas-tight seal
5. Body Material: Seamless, rotationally molded, high density polyethylene tank with minimum of 3/8" uniform wall thickness
6. Inlet and Outlet Size: As indicated.
7. Vent Connection: As indicated.
8. Mounting: Recessed, flush with floor
9. Flow-Control Fitting: Built-in
10. Liquid Holding Capacity: As indicated.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, and backfilling are specified Geotechnical Report

3.2 INSTALLATION

- A. Install precast-concrete interceptors according to ASTM C 891. Set level and plumb.
- B. Install manhole risers from top of underground concrete interceptors to manholes and gratings at finished grade.
- C. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches above finish surface elsewhere, unless otherwise indicated.
- D. Set tops of grating frames and grates flush with finished surface.

3.3 SOLIDS INTERCEPTORS

- A. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches above finish surface elsewhere, unless otherwise indicated.
- B. Set tops of grating frames and grates flush with finished surface.

3.4 CONNECTIONS

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

3.5 IDENTIFICATION

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

3.6 COMMISSIONING

- A. Commissioning Authority
 - 1. The commissioning authority (CA) has been contracted directly with the owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. However commissioning involves all parties involved with the design and construction process, including the mechanical (Division 22 & 23) contractor, and all specialty sub-contractors within Division 23, such as sheet metal, piping, refrigeration, water treatment, TAB and controls, plus major equipment suppliers as required.

END OF SECTION 221323

SECTION 221413 - 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 the following storm drainage piping inside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.
 - 3. Encasement for underground metal piping.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301. All cast iron pipe and fittings shall be manufactured in the United States.
- B. Shielded Couplings: Assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - 1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With 304 stainless-steel shield, 304 stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

2.3 ABS PIPE AND FITTINGS

- A. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.
- B. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.
- C. Solvent Cement: ASTM D 2235.
 - 1. ABS solvent cement shall have a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

PART 3 - EXECUTION

3.1 EARTH MOVING

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

3.2 PIPING INSTALLATION

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

- E. Install piping at indicated slopes.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- I. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- J. Install storm drainage piping at the following minimum slopes unless otherwise indicated:
 - 1. Building Storm Drain: 1 percent downward in direction of flow unless noted otherwise on the plans.
 - 2. Horizontal Storm-Drainage Piping: 2 percent downward in direction of flow unless noted otherwise on the plans.
- K. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- L. Install underground ABS piping according to ASTM D 2321.
- M. Plumbing Specialties:
 - 1. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers in storm drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping. Comply with requirements for cleanouts specified in Section 221423 "Storm Drainage Piping Specialties."
 - 2. Install drains in storm drainage gravity-flow piping. Comply with requirements for drains specified in Section 221423 "Storm Drainage Piping Specialties."
- N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- O. Install sleeves for piping penetrations of walls, ceilings, and floors.
- P. Install sleeve seals for piping penetrations of concrete walls and slabs.
- Q. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 JOINT CONSTRUCTION

- A. Join hub-less, cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hub-less-piping coupling joints.
- B. Plastic, Non-Pressure-Piping, Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.

3.4 SPECIALTY PIPE FITTING INSTALLATION

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

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
 - 1. Install carbon-steel pipe hangers for horizontal piping in noncorrosive environments.
 - 2. Install carbon-steel pipe support clamps for vertical piping in noncorrosive environments.
 - 3. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 4. Individual, Straight, Horizontal Piping Runs:
 - a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
 - c. Longer than 100 Feet (30 m) if Indicated: MSS Type 49, spring cushion rolls.
 - 5. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 6. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches (300 mm) of each fitting, valve, and coupling.
- C. Support vertical piping and tubing at base and at each floor.
- D. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- E. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
 4. NPS 6 and NPS 8 (DN 150 and DN 200): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
 5. NPS 10 and NPS 12 (DN 250 and DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.
 6. Spacing for 10-foot (3-m) pipe lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).
- F. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).
- G. Install hangers for ABS piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.
 2. NPS 3 (DN 80): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.
 3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.
 4. NPS 6 and NPS 8 (DN 150 and DN 200): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.
 5. NPS 10 and NPS 12 (DN 250 and DN 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.
- H. Install supports for vertical ABS piping every 48 inches (1200 mm).
- I. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

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

3.7 IDENTIFICATION

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

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Re-Inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure: Test storm drainage piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts until completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.

3.9 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. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.
- B. Aboveground storm drainage piping shall be any of the following:
 - 1. Hub-less, cast-iron soil pipe and fittings; heavy-duty, hub-less piping couplings; and coupled joints.
- C. Underground storm drainage piping shall be any of the following:
 - 1. Hub-less, cast-iron soil pipe and fittings; heavy duty hub-less piping couplings; and coupled joints.
 - 2. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.

END OF SECTION 221413

SECTION 221423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Metal roof drains.
 - 2. Miscellaneous storm drainage piping specialties.
 - 3. Cleanouts.

- B. Related Requirements:

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

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL ROOF DRAINS

- A. Cast-Iron, Medium-Sump, General-Purpose Roof Drains:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. WATTS.

- d. Zurn Industries, LLC.
- 2. Standard: ASME A112.6.4.
- 3. Body Material: Cast iron.
- 4. Dimension of Body: 8- to 12-inch diameter.
- 5. Outlet Type: No hub.
- 6. Extension Collars: Not required.
- 7. Underdeck Clamp: Required.
- 8. Expansion Joint: Not required.
- 9. Dome Material: Cast iron.
- 10. Wire Mesh: Not required.
- 11. Water Dam: 4" on Overflow drain.

2.2 CLEANOUTS

A. Cast-Iron Exposed Cleanouts:

- 1. Standard: ASME A112.36.2M.
- 2. Size: Same as connected branch.
- 3. Body Material: No-hub, cast-iron soil pipe test tee as required to match connected piping.
- 4. Closure: Countersunk, cast-iron plug.
- 5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

B. Cast-Iron Exposed Floor Cleanouts:

- 1. Standard: ASME A112.36.2M.
- 2. Size: Same as connected branch.
- 3. Type: Cast-iron soil pipe with cast-iron ferrule.
- 4. Body or Ferrule: Cast iron.
- 5. Clamping Device: Not required.
- 6. Outlet Connection: No hub.
- 7. Closure: Brass plug with straight threads and gasket.
- 8. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
- 9. Frame and Cover Shape: Round.
- 10. Top Loading Classification: Heavy Duty.
- 11. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.

C. Cast-Iron Wall Cleanouts:

- 1. Standard: ASME A112.36.2M. Include wall access.
- 2. Size: Same as connected drainage piping.
- 3. Body: No-hub, cast-iron soil pipe test tee as required to match connected piping.
- 4. Closure Plug:
 - a. Brass.
 - b. Countersunk head.
 - c. Drilled and threaded for cover attachment screw.
 - d. Size: Same as, or not more than, one size smaller than cleanout size.

5. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
6. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

D. Test Tees:

1. Standard: ASME A112.36.2M and ASTM A 74, ASTM A 888, or CISPI 301.
2. Size: Same as connected drainage piping.
3. Body Material: Hub-and-spigot, cast-iron soil-pipe T-branch or no-hub, cast-iron soil-pipe test tee as required to match connected piping.
4. Closure Plug: Countersunk, brass.
5. Closure Plug Size: Same as, or not more than, one size smaller than cleanout size.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.
 1. Install flashing collar or flange of roof drain to prevent leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Install expansion joints, if indicated, in roof drain outlets.
 3. Position roof drains for easy access and maintenance.
- B. Install conductor nozzles at exposed bottom of conductors where they spill onto grade.
- C. Install cleanouts in aboveground piping and building drain piping according to the following instructions unless otherwise indicated:
 1. Use cleanouts the same size as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 2. Locate cleanouts at each change in direction of piping greater than 45 degrees.
 3. Locate cleanouts at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 4. Locate cleanouts at base of each vertical storm piping conductor.
- D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- F. Install drain-outlet backwater valves in outlet of drains.
- G. Install test tees in vertical conductors and near floor.
- H. Install wall cleanouts in vertical conductors. Install access door in wall if indicated.

- I. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface unless otherwise indicated.
- J. Assemble channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
- K. Install through-penetration firestop assemblies for penetrations of fire- and smoke-rated assemblies.
 - 1. Comply with requirements in Section 078413 "Penetration Firestopping."

3.2 CONNECTIONS

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

3.3 FLASHING INSTALLATION

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

3.4 PROTECTION

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

END OF SECTION 221423

SECTION 221429 - SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Submersible sump pumps.

1.3 ACTION SUBMITTALS

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

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 manufacturer's written instructions for handling.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

2.2 SUBMERSIBLE SUMP PUMPS

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

1. Description: Factory-assembled and -tested sump-pump unit.
2. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
3. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
4. Impeller: Statically and dynamically balanced, ASTM A 48/A 48M, Class No. 25 A cast iron, semi-open design for clear wastewater handling, and keyed and secured to shaft.
5. Pump and Motor Shaft: Stainless steel or steel, with factory-sealed, grease-lubricated ball bearings.
6. Seal: Mechanical.
7. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump.
 - a. Motor Housing Fluid: Air.
8. Controls:
 - a. Enclosure: NEMA 250, Type 1; wall mounted.
 - b. Switch Type: Mechanical-float type, in NEMA 250, Type 6 enclosures with mounting rod and electric cables.
 - c. High-Water Alarm: Rod-mounted, NEMA 250, Type 6 enclosure with mechanical-float, mercury-float, or pressure switch matching control and electric bell; 120 V ac, with transformer and contacts for remote alarm bell.
9. Control-Interface Features:
 - a. Remote Alarm Contacts: For remote alarm interface.
 - b. Building Automation System Interface: Auxiliary contacts in pump controls for interface to building automation system and capable of providing the following:
 - 1) On-off status of pump.
 - 2) Alarm status.

2.3 MOTORS

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

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

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

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221413 "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.

3.4 FIELD QUALITY CONTROL

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

3.5 STARTUP SERVICE

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

3.6 ADJUSTING

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

3.7 DEMONSTRATION

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

END OF SECTION 221429

SECTION 221513 - GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes piping and related specialties for general-service compressed-air systems:
 - 1. Pipes, tubes, and fittings.
 - 2. Joining materials.
 - 3. Valves.
 - 4. Dielectric fittings.
 - 5. Flexible pipe connectors.
 - 6. Specialties.
 - 7. Quick couplings.
 - 8. Hose assemblies.
 - 9.
- B. Related Sections include the following:
 - 1. Section 221519 "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. CR: Chlorosulfonated polyethylene synthetic rubber.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. HDPE: High-density polyethylene plastic.
- E. NBR: Acrylonitrile-butadiene rubber.
- F. PE: Polyethylene plastic.
- G. PVC: Polyvinyl chloride plastic.
- H. High-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures between 150 and 200 psig (1035 and 1380 kPa).

- I. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig (1035 kPa) or less.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Compressed-air piping and support and installation shall withstand effects of seismic events determined according to SEI/ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 ACTION SUBMITTALS

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

1.6 INFORMATIONAL SUBMITTALS

- A. Brazing and welding certificates.
- B. Qualification Data: For installers.
- C. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

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

1.8 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Extruded-Tee Outlet Procedure: Qualify operators according to training provided by T-DRILL Industries Inc., for making branch outlets.
 - 2. Pressure-Seal Joining Procedure for Copper Tubing: Qualify operators according to training provided by Viega; Plumbing and Heating Systems.

3. Pressure-Seal Joining Procedure for Steel Piping. Qualify operators according to training provided by Victaulic Company.
 4. Joining Procedures for Aluminum Piping Systems: Qualify installers according to training provided by manufacturers.
- B. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
- C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- D. ASME Compliance:
1. Comply with ASME B31.1, "Power Piping," for high-pressure compressed-air piping.
 2. Comply with ASME B31.3, "Process Piping," for high- and low-pressure compressed-air piping.
 3. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Copper Tube: ASTM B88, Type K or L (ASTM B88M, Type A or B) seamless, drawn-temper, water tube.
1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
 2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
 3. Copper Unions: ASME B16.22 or MSS SP-123.
- B. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for compressed-air piping system contents.
1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) 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 B32, lead-free alloys. Include water-flushable flux according to ASTM B813.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

2.3 VALVES

- A. Metal Ball Valves: Comply with requirements in Section 220523.12 "Ball Valves for Plumbing Piping,"

2.4 DIELECTRIC FITTINGS

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

- B. Dielectric Unions:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Jomar International Ltd.
 - e. Matco-Norca, Inc.
 - f. McDonald, A. Y. Mfg. Co.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 250 psig (1725 kPa).
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

- C. Dielectric Flanges:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Matco-Norca, Inc.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - e. Wilkins; a Zurn company.
 - 2. Description:

- a. Standard: ASSE 1079.
- b. Factory-fabricated, bolted, companion-flange assembly.
- c. Pressure Rating: 300 psig (2070 kPa).
- d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating 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. Description:
 - a. Non-conducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 300 psig (2070 kPa).
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

2.5 FLEXIBLE PIPE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Flex-Hose Co., Inc.
 2. Flexicraft Industries.
 3. Hyspan Precision Products, Inc.
 4. Mercer Rubber Co.
 5. Metraflex, Inc.
 6. Proco Products, Inc.
 7. Unaflex, Inc.
 8. Universal Metal Hose; a Hyspan Company
- B. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 1. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
 2. End Connections, NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
 3. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.
- C. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: 200 psig (1380 kPa) minimum.
2. End Connections, NPS 2 (DN 50) and Smaller: Threaded steel pipe nipple.
3. End Connections, NPS 2-1/2 (DN 65) and Larger: Flanged steel nipple.

2.6 SPECIALTIES

- A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
 1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.
- B. Air-Line Pressure Regulators: Diaphragm operated, bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for 250-psig (1725-kPa) minimum inlet pressure, unless otherwise indicated.
- C. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig (1380-kPa) minimum working pressure, capable of automatic discharge of collected condensate.
- D. Coalescing Filters: Coalescing type with activated carbon capable of removing water and oil aerosols; with color-change dye to indicate when carbon is saturated and warning light to indicate when selected maximum pressure drop has been exceeded.
- E. Air-Line Lubricators: With drip chamber and sight dome for observing oil drop entering air stream; with oil-feed adjustment screw and quick-release collar for easy bowl removal.
 1. Provide with automatic feed device for supplying oil to lubricator.

2.7 QUICK COUPLINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Aeroquip Corporation; Eaton Corp.
 2. Bowes Manufacturing Inc.
 3. Foster Manufacturing, Inc.
 4. Milton Industries, Inc.
 5. Parker Hannifin Corp.; Fluid Connectors Group; Quick Coupling Div.
 6. Rectus Corp.
 7. Schrader-Bridgeport; Amflo Div. Schrader-Bridgeport/Standard Thomson.
 8. Snap-Tite, Inc.; Quick Disconnect & Valve Division.
 9. TOMCO Products Inc.
 10. Tuthill Corporation; Hansen Coupling Div.
- B. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose. Couplings shall include a safety release feature.

- C. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
 - 1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
 - 2. Plug End: Flow-sensor-bleeder, check-valve type with barbed outlet for attaching hose.

2.8 HOSE ASSEMBLIES

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

2.9 COMPRESSED AIR SERVICE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Chicago Faucets; Geberit Company.
- B. Service Fittings: Provide units that comply with SEFA 7, "Recommended Practices for Fixtures." Provide fittings complete with washers, locknuts, nipples, and other installation accessories. Include wall and deck flanges, escutcheons, handle extension rods, and similar items.
 - 1. Provide units that comply with "Vandal-Resistant Faucets and Fixtures" recommendations in SEFA 7.
- C. Materials: Fabricated from cast or forged red brass unless otherwise indicated.
- D. Finish: Chromium plated.
- E. Ball Valves: Chrome-plated ball and PTFE seals. Handle requires no more than 5 lbf to operate. Provide units designed for working pressure up to 125 psig, with serrated outlets.
- F. Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by "L."
- G. Handles: Provide three- or four-arm, forged-brass handles for valves unless otherwise indicated.
 - 1. Provide lever-type handles for ball valves unless otherwise indicated. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.

- H. Service-Outlet Identification: Provide color-coded plastic discs with embossed identification, secured to each service-fitting handle to be tamper resistant. Comply with SEFA 7 for colors and embossed identification.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Compressed-Air Piping between Air Compressors and Receivers: Use the following piping materials for each size range:
 - 1. NPS 2 (DN 50) and Smaller: Type K or L (Type A or B), copper tube; wrought-copper fittings; and brazed joints.
- B. Drain Piping: Use one of the following piping materials:
 - 1. NPS 2 (DN 50) and Smaller: Type M (Type C) copper tube; wrought-copper fittings; and brazed joints.

3.2 VALVE APPLICATIONS

- A. Metal Ball Valves: Comply with requirements and use valve types specified in "Valve Applications" Articles in Section 220523.12 Ball Valves for Plumbing Piping according to the following:
 - 1. High-Pressure Compressed Air: Valve types specified for medium-pressure compressed air.
 - 2. Equipment Isolation NPS 2 (DN 50) and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

3.3 SERVICE-FITTING SCHEDULE

- A. Compressed Air Service Fitting (Turret):
 - 1. Service: Compressed air.
 - 2. Fitting Type: Turret.
 - 3. Outlets: Two, at 90 degrees.
 - 4. Outlet Type: Angled.
 - 5. Valve Type: Ball valve.

3.4 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and

calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

- B. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.
- E. Install piping adjacent to equipment and machines to allow service and maintenance.
- F. Install air and drain piping with 1 percent slope downward in direction of flow.
- G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.
- H. Equipment and Specialty Flanged Connections:
 - 1. Use steel companion flange with gasket for connection to steel pipe.
 - 2. Use cast-copper-alloy companion flange with gasket and brazed or soldered joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.
- I. Flanged joints may be used instead of specified joint for any piping or tubing system.
- J. Extended-tee outlets with brazed branch connection may be used for copper tubing, within extruded-tee connection diameter to run tube diameter ratio for tube type, according to Extruded Tee Connections Sizes and Wall Thickness for Copper Tube (Inches) Table in ASTM F 2104.
- K. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.
- L. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
- M. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Section 220519 "Meters and Gages for Plumbing Piping."
- N. Install piping to permit valve servicing.
- O. Install piping free of sags and bends.
- P. Install fittings for changes in direction and branch connections.
- Q. Install seismic restraints on piping. Seismic-restraint devices are specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment."

- R. Install sleeves for piping penetrations of walls, ceilings, and floors.
- S. Install sleeve seals for piping penetrations of concrete walls and slabs.
- T. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.5 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. Welded Joints for Steel Piping: Join according to AWS D10.12/D10.12M.
- D. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- E. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.
- F. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.6 INSTALLATION OF SERVICE FITTINGS

- A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.
- B. Install fittings according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

3.7 VALVE INSTALLATION

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

3.8 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. NPS 2 (DN 50) and Smaller: Use dielectric unions.
- C. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.

3.9 FLEXIBLE PIPE CONNECTOR INSTALLATION

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

3.10 SPECIALTY INSTALLATION

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

3.11 CONNECTIONS

- A. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.
- B. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment and machine.

3.12 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- C. Vertical Piping: MSS Type 8 or 42, clamps.
- D. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 Feet (30 m) or Less: MSS Type 1, adjustable, steel clevis hangers.
 - 2. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
- E. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
- F. Base of Vertical Piping: MSS Type 52, spring hangers.
- G. Support horizontal piping within 12 inches (300 mm) of each fitting and coupling.
- H. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.
- I. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1/4 (DN 8): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
 - 2. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
 - 3. NPS 3/4 (DN 20): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
 - 4. NPS 1 (DN 25): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
 - 5. NPS 1-1/4 (DN 32): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
 - 6. NPS 1-1/2 (DN 40): 10 feet (3 m) with 3/8-inch (10-mm) rod.
 - 7. NPS 2 (DN 50): 11 feet (3.4 m) with 3/8-inch (10-mm) rod.
 - 8. NPS 2-1/2 (DN 65): 13 feet (4 m) with 1/2-inch (13-mm) rod.
- J. Install supports for vertical copper tubing every 10 feet (3 m).

3.13 LABELING AND IDENTIFICATION

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

3.14 FIELD QUALITY CONTROL

- A. Perform field tests and inspections.

B. Tests and Inspections:

1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig (345 kPa) above system operating pressure, but not less than 250 psig (1725 kPa). Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
2. Repair leaks and retest until no leaks exist.
3. Inspect filters, lubricators and pressure regulators for proper operation.

C. Prepare test reports.

END OF SECTION 221513

SECTION 221519 - GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

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. Oilless, scroll air compressors.
 - 2. Inlet-air filters.
 - 3. Air-cooled, compressed-air aftercoolers.
 - 4. Refrigerant compressed-air dryers.

1.3 DEFINITIONS

- A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in acfm.
- B. Standard Air: Free air at 68 deg F and 1 atmosphere before compression or expansion and measured in scfm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For compressed-air equipment mounting.
 - 1. Detail fabrication and assembly of supports.
 - 2. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Air-Compressor, Inlet-Air-Filter Elements: Equal to 10 percent of amount installed, but no fewer than 2 units.
 - 2. Belts: Two for each belt-driven compressor.

1.7 COORDINATION

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

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design compressed-air equipment mounting.
- B. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2.3 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

- A. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

- B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
 - 1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 - 2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 - 3. Control Voltage: 120-V ac or less, using integral control power transformer.
 - 4. Motor Overload Protection: Overload relay in each phase.
 - 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 - 6. Automatic control switches to air compressors.
 - 7. Instrumentation: Include discharge-air pressure gage, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gages, and control transformer.
 - 8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
- C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
 - 2. Interior Finish: Corrosion-resistant coating.
 - 3. Accessories: Include safety valve, pressure gage, drain, and pressure-reducing valve.
- D. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.
 - a.

2.4 OILLESS, SCROLL AIR COMPRESSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ingersoll-Rand.
 - 2. Powerex, Inc.
 - 3. Quincy Compressor.
- B. Compressor(s): Oilless (nonlubricated), rotary scroll type, with serviceable bearings external to air compression chamber, that deliver air of quality equal to intake air.
 - 1. High discharge-air temperature switch.
 - 2. Belt guard totally enclosing pulleys and belts.
- C. Capacities and Characteristics: As indicated.

- D. Integral Air-Cooled Aftercooler: Sized to provide an approach temperature of 20° F. Corrosion resistant metals.
- E. Sound Reducing Enclosure: Internal frame, steel base, individual vibration isolation mounted compressor module, side access panels, side cooling air intakes.
- F. Drain Valve: Automatic solenoid timer, no loss type, discharge silencer.

2.5 INLET-AIR FILTERS

- A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
 - 1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 - 2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.
- B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.
 - 1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 - 2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.
 - 3.

2.6 REFRIGERANT COMPRESSED-AIR DRYERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Atlas Copco.
 - 2. Hankison International.
 - 3. Zeks
- B. Description: Cycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35 deg F, 100-psig air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gages, thermometers, automatic controls, and filters.
- C. Capacities and Characteristics:
 - 1. Standard-Air Capacity of Each Compressed-Air Dryer: 24 free air.
 - 2. Pressure: 100 psig.
 - 3. Entering-Air Temperature: 100° F.
 - 4. Ambient-Air Temperature: 100° F.
 - 5. Maximum Air-Pressure Drop: <Insert psig>.

6. Motor Power: 0.45 kW.
7. Electrical Characteristics:
 - a. Volts: 115.
 - b. Phase(s): 1.
 - c. Hertz: 60.
8. Accessories:
 - a. No loss drain with discharge silencer.
 - b. External gauge package, pressure and temperature.

2.7 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 220513 "Common Motor Requirements for Plumbing Equipment."
 1. Enclosure: Totally enclosed, fan cooled.
 2. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load does not require motor to operate in service factor range above 1.0.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Equipment Mounting:
 1. Install air compressors, aftercoolers, and air dryers on cast-in-place concrete equipment base(s).
 2. Comply with requirements for vibration isolation and seismic control devices specified in Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment"
 3. Comply with requirements for vibration isolation devices specified in Section 220548.13 "Vibration Controls for Plumbing Piping and Equipment."
- B. Install compressed-air equipment anchored to substrate.
- C. Arrange equipment so controls and devices are accessible for servicing.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Install the following devices on compressed-air equipment:
 1. Thermometer, Pressure Gage, and Safety Valve: Install on each compressed-air receiver.
 2. Pressure Regulators: Install downstream from air compressors.
 3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.2 CONNECTIONS

- A. Comply with requirements for piping specified in Section 221513 "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to machine, allow space for service and maintenance.

3.3 IDENTIFICATION

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

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. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that air-compressor inlet filters and piping are clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors, and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure, but not higher than rating of system components.
 - 7. Check for proper seismic restraints.
 - 8. Drain receiver tanks.
 - 9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 10. Test and adjust controls and safeties.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air compressors, aftercoolers, and air dryers.

END OF SECTION 221519

SECTION 223400 - FUEL-FIRED, DOMESTIC-WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Commercial, gas-fired, high-efficiency, storage, domestic-water heaters.
 - 2. Domestic-water heater accessories.

1.3 SUBMITTALS

- A. Product Data: For each type and size of domestic-water heater indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.
- D. Operation and Maintenance Data: For fuel-fired, domestic-water heaters to include in emergency, operation, and maintenance manuals.
- E. Warranty.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE/IESNA 90.1 Compliance: Fabricate and label fuel-fired, domestic-water heaters to comply with ASHRAE/IESNA 90.1.

C. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial, domestic-water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

D. NSF Compliance: Fabricate and label equipment components that will be in contact with potable water to comply with NSF 61, "Drinking Water System Components - Health Effects."

1.5 COORDINATION

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

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
2. Warranty Periods: From date of Substantial Completion.
 - a. Commercial, Gas-Fired, Storage, Domestic-Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: Three years.
 - b. Compression Tanks: Five years.

PART 2 - PRODUCTS

2.1 COMMERCIAL, GAS-FIRED, STORAGE, DOMESTIC-WATER HEATERS

- A. Commercial, Gas-Fired, High-Efficiency, Storage, Domestic-Water Heaters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AERCO International, Inc.
 - b. Lochinvar Corporation.
 - c. PVI Industries, LLC.
 - d. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.

2. Standard: ANSI Z21.10.3/CSA 4.3.
3. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions.
4. Storage-Tank Construction: ASME-code steel with 150-psig (1035-kPa) minimum working-pressure rating.
 - a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - 1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
 - 2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
 - b. 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.
5. Factory-Installed Storage-Tank Appurtenances:
 - a. Anode Rod: Powered, non-sacrificial
 - b. Dip Tube: Required unless cold-water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for gas-fired, high-efficiency, domestic-water heaters and natural-gas fuel.
 - g. Temperature Control: Adjustable thermostat.
 - h. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.
 - i. Combination Temperature-and-Pressure Relief Valves: ANSI Z21.22/CSA 4.4-M. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

2.2 DOMESTIC-WATER HEATER ACCESSORIES

A. Domestic-Water Compression Tanks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL Inc.
 - b. Smith, A. O. Water Products Co.; a division of A. O. Smith Corporation.
 - c. Taco, Inc.

- d. Watts
- 2. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air pre-charge to minimum system-operating pressure at tank.
- 3. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
- B. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS 3/4 (DN 20) with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.
- C. Gas Shutoff Valves: ANSI Z21.15/CSA 9.1-M, manually operated. Furnish for installation in piping.
- D. Gas Pressure Regulators: ANSI Z21.18/CSA 6.3, appliance type. Include 2-psig pressure rating as required to match gas supply.
- E. Automatic Gas Valves: ANSI Z21.21/CSA 6.5, appliance, electrically operated, on-off automatic valve.
- F. Domestic-Water Heater Stands: Manufacturer's factory-fabricated steel stand for floor mounting, capable of supporting domestic-water heater and water. Provide dimension that will support bottom of domestic-water heater a minimum of 18 inches (457 mm) above the floor.
- G. Domestic-Water Heater Mounting Brackets: Manufacturer's factory-fabricated steel bracket for wall mounting, capable of supporting domestic-water heater and water.
- H. Concentric Combustion Flue Air Intake Fitting: Manufacturer's factory-fabricated fitting for combining flue and combustion air into a single piece.

PART 3 - EXECUTION

3.1 DOMESTIC-WATER HEATER INSTALLATION

- A. Commercial, Domestic-Water Heater Mounting: Install commercial domestic-water heaters on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete."
 - 1. Exception: Omit concrete bases for commercial domestic-water heaters if installation on stand, bracket, suspended platform, or directly on floor is indicated.
 - 2. Maintain manufacturer's recommended clearances.

3. Arrange units so controls and devices that require servicing are accessible.
 4. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 5. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 6. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 7. Install anchor bolts to elevations required for proper attachment to supported equipment.
 8. Anchor domestic-water heaters to substrate.
- B. Install domestic-water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
1. Install shutoff valves on domestic-water-supply piping to domestic-water heaters and on domestic-hot-water outlet piping. Comply with requirements for shutoff valves specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- C. Install gas-fired, domestic-water heaters according to NFPA 54.
1. Install gas shutoff valves on gas supply piping to gas-fired, domestic-water heaters without shutoff valves.
 2. Install gas pressure regulators on gas supplies to gas-fired, domestic-water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
 3. Install automatic gas valves on gas supplies to gas-fired, domestic-water heaters if required for operation of safety control.
- D. Install commercial domestic-water heaters with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."
- E. Install combination temperature-and-pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic-water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heaters that do not have tank drains. Comply with requirements for hose-end drain valves specified in Division 22 Section "Domestic Water Piping Specialties."
- G. Install thermometer on outlet piping of domestic-water heaters. Comply with requirements for thermometers specified in Division 22 Section "Meters and Gages for Plumbing Piping."
- H. Fill domestic-water heaters with water.
- I. Charge domestic-water compression tanks with air.

3.2 CONNECTIONS

- A. Comply with requirements for domestic-water piping specified in Division 22 Section "Domestic Water Piping."
- B. Comply with requirements for gas piping specified in Division 22 Section "Facility Natural-Gas Piping."
- C. Drawings indicate general arrangement of piping, fittings, and specialties.
- D. Where installing piping adjacent to fuel-fired, domestic-water heaters, allow space for service and maintenance of water heaters. Arrange piping for easy removal of domestic-water heaters.

3.3 IDENTIFICATION

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

3.4 FIELD QUALITY CONTROL

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

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial, gas-fired, storage, domestic-water heaters.

3.6 COMMISSIONING

- A. The equipment and systems referenced in this section are to be commissioned per Section 019113 – General Commissioning Requirements and Section 220800 - Commissioning of Plumbing. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 223400

SECTION 224213.13 - COMMERCIAL WATER CLOSETS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Water closets.
 - 2. Flushometer valves and tanks.
 - 3. Toilet seats.
 - 4. Supports.

1.3 DEFINITIONS

- A. Effective Flush Volume: Average of two reduced flushes and one full flush per fixture.
- B. Remote Water Closet: Located more than 30 feet from other drain line connections or fixture and where less than 1.5 drainage fixture units are upstream of the drain line connection.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for water closets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For flushometer valves to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Flushometer-Valve Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than one of each type.

PART 2 - PRODUCTS

2.1 WALL-MOUNTED WATER CLOSETS

- A. Water Closets: Wall mounted, top spud, accessible.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - 2. Bowl:
 - a. Standards: ASME A112.19.2/CSA B45.1 and ASME A112.19.5.
 - b. Material: Vitreous china.
 - c. Type: Siphon jet.
 - d. Style: Flushometer valve.
 - e. Height: Standard.
 - f. Rim Contour: Elongated.
 - g. Water Consumption: 1.28 gal. per flush.
 - h. Spud Size and Location: NPS 1-1/2; top.
 - 3. Support: Water closet carrier.
 - 4. Water-Closet Mounting Height: As indicated on drawings..

2.2 FLUSHOMETER VALVES

- A. Lever-Handle, Diaphragm Flushometer Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Sloan Valve Company.
 - 2. Standard: ASSE 1037.
 - 3. Minimum Pressure Rating: 125 psig.
 - 4. Features: Include integral check stop and backflow-prevention device.
 - 5. Material: Brass body with corrosion-resistant components.
 - 6. Exposed Flushometer-Valve Finish: Chrome plated.

7. Panel Finish: Chrome plated or stainless steel.
8. Style: Exposed.
9. Consumption: 1.28 gal. per flush.
10. Minimum Inlet: NPS 1.
11. Minimum Outlet: NPS 1-1/4.

2.3 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard Companies, Inc.
 - b. Bemis Manufacturing Company.
 - c. Kohler Co.
2. Standard: IAPMO/ANSI Z124.5.
3. Material: Plastic.
4. Type: Commercial (Standard).
5. Shape: Elongated rim, open front.
6. Hinge: Check.
7. Hinge Material: Noncorroding metal.
8. Seat Cover: Not required.
9. Color: White.

2.4 SUPPORTS

A. Water Closet Carrier:

1. Standard: ASME A112.6.1M.
2. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

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 water-closet installation.
- B. Examine walls and floors for suitable conditions where water closets will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Water-Closet Installation:

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

B. Support Installation:

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

C. Flushometer-Valve Installation:

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

D. Install toilet seats on water closets.

E. Wall Flange and Escutcheon Installation:

1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
2. Install deep-pattern escutcheons if required to conceal protruding fittings.
3. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."

F. Joint Sealing:

1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
2. Match sealant color to water-closet color.
3. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect water closets with water supplies and soil, waste, and vent piping. Use size fittings required to match water closets.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."
- D. Where installing piping adjacent to water closets, allow space for service and maintenance.

3.4 ADJUSTING

- A. Operate and adjust water closets and controls. Replace damaged and malfunctioning water closets, fittings, and controls.
- B. Adjust water pressure at flushometer valves to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. Clean water closets and fittings with manufacturers' recommended cleaning methods and materials.
- B. Install protective covering for installed water closets and fittings.
- C. Do not allow use of water closets for temporary facilities unless approved in writing by Owner.

END OF SECTION 224213.13

SECTION 224216.13 - COMMERCIAL LAVATORIES

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. Lavatories.
2. Faucets.
3. Supply fittings.
4. Waste fittings.
5. Supports.

1.3 ACTION SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for lavatories.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

- B. Shop Drawings: Include diagrams for power, signal, and control wiring of automatic faucets.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lavatories and faucets to include in operation and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Servicing and adjustments of automatic faucets.

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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 - 2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 VITREOUS-CHINA, WALL-MOUNTED LAVATORIES

- A. Lavatory: Vitreous china, wall mounted, with back.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Standard.
 - b. Kohler Co.
 - c. Sloan Valve Company.
 - 2. Fixture:
 - a. Standard: ASME A112.19.2/CSA B45.1.
 - b. Type: For wall hanging.
 - c. Nominal Size: Oval, 19 by 16 inches.
 - d. Faucet-Hole Punching: Three holes, 4-inch centers.
 - e. Faucet-Hole Location: Top.
 - f. Color: White.
 - g. Mounting Material: Chair carrier.
 - 3. Support: Type I, exposed-arm lavatory carrier.
 - 4. Lavatory Mounting Height: Handicapped/elderly according to ICC A117.1.

2.2 SOLID-BRASS, MANUALLY OPERATED FAUCETS

- A. NSF Standard: Comply with NSF 372 for faucet materials that will be in contact with potable water.
- B. Lavatory Faucets: Manual-type, single-control mixing, commercial, solid-brass valve.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Chicago Faucets; Geberit Company.

2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
4. Body Type: Centerset.
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 0.5 gpm.
8. Mounting Type: Deck, concealed.
9. Valve Handle(s): Single lever.
10. Spout: Rigid type.
11. Spout Outlet: Aerator.
12. Operation: Noncompression, manual.
13. Drain: Not part of faucet.

C. Lavatory Faucets: Manual-type, single-control mixing, commercial, solid-brass valve.

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Chicago Faucets; Geberit Company.
2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and fixture receptor.
4. Body Type: Centerset.
5. Body Material: Commercial, solid brass.
6. Finish: Polished chrome plate.
7. Maximum Flow Rate: 0.5 gpm.
8. Maximum Flow: 0.25 gal. per metering cycle.
9. Mounting Type: Deck, concealed.
10. Valve Handle(s): Push button.
11. Spout: Rigid type.
12. Spout Outlet: Aerator.
13. Operation: Compression, manual.
14. Drain: Not part of faucet.

2.3 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Supply Piping: Chrome-plated-brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated-brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated-brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.

E. Operation: Loose key.

F. Risers:

1. NPS 1/2.
2. Chrome-plated, rigid-copper-pipe and brass straight or offset tailpieces riser.

2.4 WASTE FITTINGS

A. Standard: ASME A112.18.2/CSA B125.2.

B. Drain: Grid type with NPS 1-1/4 offset and straight tailpiece.

C. Trap:

1. Size: NPS 1-1/2 by NPS 1-1/4.
2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated, brass or steel wall flange.

2.5 SUPPORTS

A. Type II Lavatory Carrier:

1. Standard: ASME A112.6.1M.

B. Type III Lavatory Carrier:

1. Standard: ASME A112.6.1M.

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 lavatory installation.
- B. Examine counters and walls for suitable conditions where lavatories will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install lavatories level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-mounted lavatories.

- C. Install accessible wall-mounted lavatories at handicapped/elderly mounting height for people with disabilities or the elderly, according to ICC/ANSI A117.1.
- D. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- E. Seal joints between lavatories, counters, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- F. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible lavatories. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.
- C. Install fresh batteries in battery-powered, electronic-sensor mechanisms.

3.5 CLEANING AND PROTECTION

- A. After completing installation of lavatories, inspect and repair damaged finishes.
- B. Clean lavatories, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed lavatories and fittings.
- D. Do not allow use of lavatories for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.13

SECTION 224216.16 - COMMERCIAL SINKS

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. Service sinks.
2. Utility sinks.
3. Lab sinks.
4. Sink faucets.
5. Laminar-flow, faucet-spout outlets.
6. Supports.
7. Supply fittings.
8. Waste fittings.

1.3 ACTION SUBMITTALS

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

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for sinks.
2. Include rated capacities, operating characteristics and furnished specialties and accessories.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.

PART 2 - PRODUCTS

2.1 SERVICE SINKS

A. Service Sinks MS-1: Enameled, cast iron trap, 6" recess mounted.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkay Manufacturing Co.
2. Fixture:
 - a. Standard: ASME A112.19.1/CSA B45.2.
 - b. Type: Service sink with back.
 - c. Nominal Size: 24x36".
 - d. Color: White.
 - e. Mounting: NPS 2 P-trap standard with grid strainer inlet, cleanout, and floor flange.
 - f. Rim Guard: On front and sides.

2.2 SINGLE COMPARTMENT SINKS

A. Sinks; One-compartment, counter-mounting, stainless-steel commercial, classroom.

1. Basis-of-Design Product: Subject to compliance with requirements, product by the following:
 - a. Elkay Manufacturing Co.
2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Nominal Size: Approximately 19-1/2 by 19 by 6-1/2 inches
Construction: Seamless die-drawn, 18 gauge type 304 stainless steel. Self-rimming top with stainless steel mounting channels. Fully coated underside for sound deadening and condensation reduction.
3. Faucet: Comply with requirements in "Supply Fittings" Article.
 - a. Location: Back ledge

4. Supply Fittings: Comply with requirements in "Sink Faucets" Article.
5. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Bowl: Drain
 - 1) Drain: Grid and NPS 1-1/2tailpiece.
 - 2) Drain Piping: NPS 1-1/2chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.

2.3 TWO-COMPARTMENT SINKS

- A. Two-compartment Sinks; two-compartment, counter-mounting, stainless-steel commercial sink.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product by one of the following:
 - a. Elkay Manufacturing Co.
 2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Nominal Size: Approximately 43 by 22 by 7 inchesConstruction: Seamless die-drawn, 18 gauge type 304 stainless steel. Self-rimming top with stainless steel mounting channels. Fully coated underside for sound deadening and condensation reduction.
 3. Faucet: Comply with requirements in "Supply Fittings" Article.
 - a. Location: Back ledge
 4. Supply Fittings: Comply with requirements in "Sink Faucets" Article.
 5. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Bowl: Drains
 - 1) Drain: Grid and NPS 1-1/2tailpiece.
 - 2) Drain Piping: NPS 1-1/2chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.

2.4 COMMERCIAL SINKS

- A. Two-compartment Sinks; single-compartment, counter-mounting, stainless-steel commercial sink.
 1. Basis-of-Design Product: Subject to compliance with requirements, provide the product by the following:

- a. Elkay Manufacturing Co.
2. Fixture:
 - a. Standard: ASME A112.19.3/CSA B45.4.
 - b. Nominal Size: Approximately 15 by 17 by 6 inches
Construction: Seamless die-drawn, 18 gauge type 304 stainless steel. Self-rimming top with stainless steel mounting channels. Fully coated underside for sound deadening and condensation reduction.
3. Faucet: Comply with requirements in "Supply Fittings" Article.
 - a. Location: Back ledge
4. Supply Fittings: Comply with requirements in "Sink Faucets" Article.
5. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.
 - b. Bowl: Drains
 - 1) Drain: Grid and NPS 1-1/2 tailpiece.
 - 2) Drain Piping: NPS 1-1/2 chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.

2.5 LAB SINKS

A. MANUFACTURERS

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Chemtops.
 - b. Durcon
 - c. Resintop.

B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Architect.

1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2, unless otherwise indicated.

C. Overflows: For each sink, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches less than sink depth. Provide in same material as strainer.

D. Faucet: Comply with requirements in "Supply Fittings" Article.

1. Location: Side.
2. Supply Fittings: Comply with requirements in "Sink Faucets" Article.
3. Waste Fittings:
 - a. Standard: ASME A112.18.2/CSA B125.2.

b. Bowl: Drain

1) Drain: Grid and NPS 1-1/2tailpiece.

4. Drain Piping: NPS 1-1/2chrome-plated, tubular-brass direct waste without trap, separate waste piping, and wall flange.

2.6 SINK FAUCETS

- A. NSF Standard: Comply with NSF 372 for faucet-spout materials that will be in contact with potable water.

- B. Sink Faucets: Manual type, two lever handle mixing valve.

1. Commercial, Solid-Brass Faucets:

- a. Manufacturers: Subject to compliance with requirements, provide products by the following:

1) Chicago Faucets; Geberit Company.

2. Standard: ASME A112.18.1/CSA B125.1.
3. General: Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture hole punchings; coordinate outlet with spout and sink receptor.
4. Body Type: Centerset.
5. Body Material: Commercial, solid brass.
6. Finish: Chrome plated.
7. Maximum Flow Rate: 2.2 gpm.
8. Handle(s): Lever.
9. Mounting Type: Deck, concealed.
10. Spout Type: Swing, round tubular or Rigid gooseneck or Swivel gooseneck.
11. Vacuum Breaker: Required for hose outlet.
12. Spout Outlet: Aerator.

2.7 LAMINAR-FLOW, FAUCET-SPOUT OUTLETS

- A. NSF Standard: Comply with NSF 372 for faucet-spout-outlet materials that will be in contact with potable water.

- B. Description: Chrome-plated brass, faucet-spout outlet that produces non-aerating, laminar stream. Include external or internal thread that mates with faucet outlet for attachment to faucets where indicated and flow-rate range that includes flow of faucet.

2.8 SUPPORTS

- A. Type II Sink Carrier:

1. Standard: ASME A112.6.1M.

2.9 SUPPLY FITTINGS

- A. NSF Standard: Comply with NSF 372 for supply-fitting materials that will be in contact with potable water.
- B. Standard: ASME A112.18.1/CSA B125.1.
- C. Supply Piping: Chrome-plated brass pipe or chrome-plated copper tube matching water-supply piping size. Include chrome-plated brass or stainless-steel wall flange.
- D. Supply Stops: Chrome-plated brass, one-quarter-turn, ball-type or compression valve with inlet connection matching supply piping.
- E. Operation: Loose key.
- F. Risers:
 - 1. NPS 3/8.
 - 2. Chrome-plated, rigid-copper pipe.

2.10 WASTE FITTINGS

- A. Standard: ASME A112.18.2/CSA B125.2.
- B. Drain: Grid type with NPS 1-1/2 offset and straight tailpiece.
- C. Trap:
 - 1. Size: NPS 1-1/2.
 - 2. Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch-thick brass tube to wall; and chrome-plated brass or steel wall flange.
 - 3. Material: Stainless-steel, two-piece trap and swivel elbow with 0.012-inch-thick stainless-steel tube to wall; and stainless-steel wall flange.

2.11 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 EXAMINATION

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

3.2 INSTALLATION

- A. Install sinks level and plumb according to roughing-in drawings.
- B. Install supports, affixed to building substrate, for wall-hung sinks.
- C. Install accessible wall-mounted sinks at handicapped/elderly mounting height according to ICC/ANSI A117.1.
- D. Set floor-mounted sinks in leveling bed of cement grout.
- E. Install water-supply piping with stop on each supply to each sink faucet.
 - 1. Install stops in locations where they can be easily reached for operation.
- F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons if required to conceal protruding fittings. Comply with escutcheon requirements specified in Section 220518 "Escutcheons for Plumbing Piping."
- G. Seal joints between sinks and counters, floors, and walls using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."
- H. Install protective shielding pipe covers and enclosures on exposed supplies and waste piping of accessible sinks. Comply with requirements in Section 220719 "Plumbing Piping Insulation."

3.3 CONNECTIONS

- A. Connect sinks with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

- A. Operate and adjust sinks and controls. Replace damaged and malfunctioning sinks, fittings, and controls.
- B. Adjust water pressure at faucets to produce proper flow.

3.5 CLEANING AND PROTECTION

- A. After completing installation of sinks, inspect and repair damaged finishes.
- B. Clean sinks, faucets, and other fittings with manufacturers' recommended cleaning methods and materials.
- C. Provide protective covering for installed sinks and fittings.
- D. Do not allow use of sinks for temporary facilities unless approved in writing by Owner.

END OF SECTION 224216.16

SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Emergency showers.
2. Eyewash equipment.
3. Eye/face wash equipment.
4. Combination units.
5. Supplemental equipment.
6. Water-tempering equipment.

1.3 DEFINITIONS

- A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.
- B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.
- C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.
- D. Tepid: Moderately warm.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.
- B. Shop Drawings:
 1. Include plans, elevations, sections, and mounting attachment details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

4. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.
- B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For emergency plumbing fixtures to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Flushing-Fluid Solution: Separate lot and equal to at least 200 percent of amount of solution installed for each self-contained unit.

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. ISEA Standard: Comply with ISEA Z358.1.
- C. NSF Standard: Comply with NSF 61 and NSF 372, for fixture materials that will be in contact with potable water.
- D. Regulatory Requirements: Comply with requirements in ICC A117.1; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

2.2 COMBINATION UNITS

- A. Standard, Plumbed Emergency Shower with Eyewash Combination Units:
 1. Manufacturers: Subject to compliance with requirements, provide products by the following:

- a. Haws Corporation.
2. Piping:
 - a. Material: Galvanized steel.
 - b. Unit Supply: NPS 1-1/2.
 - c. Unit Drain: Outlet at back or side near bottom.
3. Shower:
 - a. Capacity: Not less than 20 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Pull rod.
 - d. Shower Head: 8-inch-minimum diameter, chrome-plated brass or stainless steel.
 - e. Mounting: Pedestal.
4. Eyewash Unit:
 - a. Capacity: Not less than 0.4 gpm for at least 15 minutes.
 - b. Supply Piping: NPS 1/2 with flow regulator and stay-open control valve.
 - c. Control-Valve Actuator: Paddle.
 - d. Spray-Head Assembly: Two receptor-mounted spray heads.
 - e. Receptor: Chrome-plated brass or stainless-steel or Plastic bowl.
 - f. Mounting: Attached shower pedestal.
 - g. Drench-Hose Option: May be provided instead of eyewash unit.
 - 1) Capacity: Not less than 0.4 gpm for at least 15 minutes.
 - 2) Drench Hose: Hand-held spray head with squeeze-handle actuator and hose.
 - 3) Mounting: Bracket on shower pedestal.

2.3 WATER-TEMPERING EQUIPMENT

A. Hot- and Cold-Water, Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Lawler Manufacturing Company, Inc.
 - b. Leonard Valve Company.
2. Description: Factory-fabricated equipment with thermostatic mixing valve.
 - a. Thermostatic Mixing Valve: Designed to provide 85 deg F tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.
 - b. Supply Connections: For hot and cold water.

2.4 SOURCE QUALITY CONTROL

- A. Certify performance of emergency plumbing fixtures by independent testing organization acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF EMERGENCY PLUMBING FIXTURE INSTALLATION

- A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.
- B. Install fixtures level and plumb.
- C. Fasten fixtures to substrate.
- D. Install shutoff valves in water-supply piping to fixtures, to facilitate maintenance of the equipment. Use ball or gate valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Comply with requirements for valves specified in Section 220523.12 "Ball Valves for Plumbing Piping" and Section 220523.15 "Gate Valves for Plumbing Piping."
 - 1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency equipment.
 - 2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.
- E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- F. Install dielectric fitting in supply piping to emergency equipment if piping and equipment connections are made of different metals. Comply with requirements for dielectric fittings specified in Section 221116 "Domestic Water Piping."
- G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Comply with requirements for thermometers specified in Section 220519 "Meters and Gages for Plumbing Piping."

- H. Install trap and waste piping on drain outlet of emergency equipment receptors that are indicated to be directly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- I. Install indirect waste piping on drain outlet of emergency equipment receptors that are indicated to be indirectly connected to drainage system. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Comply with requirements for escutcheons specified in Section 220518 "Escutcheons for Plumbing Piping."
- K. Fill self-contained fixtures with flushing fluid.

3.3 CONNECTIONS

- A. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- B. Connect hot- and cold-water-supply piping to hot- and cold-water, water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for hot- and cold-water piping specified in Section 221116 "Domestic Water Piping."
- C. Connect steam and cold-water-supply and condensate return piping to steam and cold water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping" and comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping" and Section 232216 "Steam and Condensate Heating Piping Specialties."
- D. Connect cold water and electrical power to electric heating water-tempering equipment. Comply with requirements for cold-water piping specified in Section 221116 "Domestic Water Piping."
- E. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary waste and vent piping. Comply with requirements for waste piping specified in Section 221316 "Sanitary Waste and Vent Piping."
- F. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary waste or storm drainage piping.
- G. Where installing piping adjacent to emergency plumbing fixtures, allow space for service and maintenance of fixtures.

3.4 IDENTIFICATION

- A. Install equipment nameplates or equipment markers on emergency plumbing fixtures and equipment and equipment signs on water-tempering equipment. Comply with requirements for identification materials specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities.
- B. 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 unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Emergency plumbing fixtures and water-tempering equipment will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust or replace fixture flow regulators for proper flow.
- B. Adjust equipment temperature settings.

END OF SECTION 224500

SECTION 224713 - DRINKING FOUNTAINS

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 drinking fountains and related components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of drinking fountain.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include operating characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For drinking fountains to include in maintenance manuals.

PART 2 - PRODUCTS

2.1 DRINKING FOUNTAINS

- A. Drinking Fountains, DF-2: Stainless steel, wall hung; Delivers non-chilled drinking water with bottle-filler
 - 1. Stainless-Steel Drinking Fountains:
 - a. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1) Elkay Manufacturing Co.
 - 2) Halsey Taylor.
 - 3) Haws Corporation.
 - 4) Sunroc Co.

2. Standards:
 - a. Comply with ADA, ANSI/NSF 61
3. Receptor Shape: Rectangular
4. Bottle filler: provide 1.1-1.5 gpm flow rate
5. Back Panel: Stainless-steel wall plate behind drinking fountain.
6. Bubblers: One, with adjustable stream regulator, located on deck.
7. Control: Push button for bubbler, electronic sensor with auto 20-second shut-off timer for bottle filler
8. Drain: Grid type with NPS 1-1/2 tailpiece.
9. Supply: NPS 3/8 with shutoff valve.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 chrome-plated brass P-trap and waste.
11. Support: ASME A112.6.1M, Type III lavatory carrier.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Install fixtures level and plumb according to roughing-in drawings. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- B. Install recessed drinking fountains secured to wood blocking in wall construction.
- C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Sections 220523.12 "Ball Valves for HVAC Piping", 230523.13 "Butterfly Valves for HVAC Piping", and 230523.14 "Check Valves for HVAC Piping."
- E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

- F. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding fittings. Comply with escutcheon requirements specified in 220500 "Common Work Results For Plumbing".
- G. Seal joints between fixtures and walls using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Comply with sealant requirements specified in Section 079200 "Joint Sealants."

3.3 CONNECTIONS

- A. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- B. Comply with water piping requirements specified in Section 221116 "Domestic Water Piping."
- C. Install ball, gate, or globe shutoff valve on water supply to each fixture. Comply with valve requirements specified in Sections 220523.12 "Ball Valves for HVAC Piping", 230523.13 "Butterfly Valves for HVAC Piping", and 230523.14 "Check Valves for HVAC Piping."
- D. Comply with soil and waste piping requirements specified in Section 221316 "Sanitary Waste and Vent Piping."

3.4 ADJUSTING

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

3.5 CLEANING

- A. After installing fixtures, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.
- C. Provide protective covering for installed fixtures.
- D. Do not allow use of fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 224713

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC 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 the following:
 - 1. 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.
 - 2. Enclosed controllers rated 600 V and less:
 - a. Full-voltage manual.
 - b. Reduced voltage magnetic.

1.3 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
- B. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

- A. Product Data: For each type of enclosed controller.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.
- D. Field quality-control reports.
- E. Operation and maintenance data.

1.6 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. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems".

1.8 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

2. Control Power Fuses: Equal 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: two of each type and color installed.
4. Auxiliary Contacts: Furnish two spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

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

I. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.5 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: Pre-lubricated, 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 FULL-VOLTAGE CONTROLLERS

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 - 2. Configuration: Non-reversing.
 - 3. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type.
 - 4. Surface mounting.
 - 5. Green pilot light.

2.7 REDUCED-VOLTAGE MAGNETIC CONTROLLERS

- A. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
- B. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage, electrically held magnetic controller and disconnecting means.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - c. Rockwell Automation, Inc.; Allen-Bradley brand.
 - d. Siemens Energy & Automation, Inc.
 - e. Square D; a brand of Schneider Electric.
 - 2. Configuration:
 - a. Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.

3. Contactor Coils: Pressure-encapsulated type.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 200 VA.
6. Bimetallic Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 20 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.
7. External overload reset push button.
8. Non-fusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, non-fusible switch.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2.8 ENCLOSURES

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
 1. Dry and Clean Indoor Locations: Type 1.
 2. Outdoor Locations: Type 3R.
 3. Kitchen or Wash-Down Areas: Type 4X.
 4. Other Wet or Damp Indoor Locations: Type 4.
 5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.9 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
 - 1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty.
 - a. Push Buttons: Unguarded types; maintained or momentary as indicated.
 - b. Pilot Lights: LED types; colors as indicated.
- B. Reversible N.C./N.O. auxiliary contact(s).
- C. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4, Type 4X, and Type 7 enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- D. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R and Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
- E. Spare control wiring terminal blocks, quantity as indicated; wired.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- B. Seismic Bracing: Comply with requirements specified in Division 26 Section "Seismic Controls for Electrical Systems."
- C. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- D. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- E. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- F. Comply with NECA 1.
- G. Unless otherwise specified, motor controllers for all motors shall be provided by mechanical contractor.

3.2 IDENTIFICATION

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 23 Section "Identification for HVAC Piping and Equipment."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers and remote devices. Comply with requirements in Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
- D. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 ADJUSTING

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.
- D. Set the taps on reduced-voltage autotransformer controllers at 80 percent.

3.5 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.6 DEMONSTRATION

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

3.7 COMMISSIONING

- A. The equipment and systems referenced in this section are to be commissioned per Section 019113 – General Commissioning Requirements and Section 230800 – Commissioning of HVAC. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

END OF SECTION 230513

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Sleeves.
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.
 - 6. Silicone sealants.

- B. Related Requirements:

- 1. Section 078413 "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.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 SLEEVES

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

- 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.

- B. Cast-Iron Pipe Sleeves: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop collar.
- C. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, anti-corrosion coated or zinc coated, with plain ends and integral welded waterstop collar.
- D. Galvanized-Steel Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- E. PVC Pipe Sleeves: ASTM D 1785, Schedule 40.
- F. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- G. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
- B. Description: Manufactured, galvanized cast-iron sleeve with integral cast flashing flange for use in waterproof floors and roofs. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. Metraflex Company (The).
- B. Description:
 - 1. Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
 - 2. Designed to form a hydrostatic seal of 20-psig.
 - 3. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size.

4. Pressure Plates: Carbon steel.
5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 633 of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Advance Products & Systems, Inc.
 2. CALPICO, Inc.
 3. Metraflex Company (The).
- B. Description:
 1. Manufactured plastic, sleeve-type, waterstop assembly, made for imbedding in concrete slab or wall.
 2. Plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

- A. Description: Nonshrink, recommended for interior and exterior sealing openings in nonfire-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.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 3. Using grout, seal 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 sealants appropriate for size, depth, and location of joint.
- E. Fire-Resistance-Rated Penetrations, Horizontal Assembly Penetrations, and Smoke-Barrier Penetrations: Maintain indicated fire or smoke rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping and fill materials specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 3 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 waterproof silicone sealant, seal space between top hub of stack-sleeve fitting and pipe.
- B. Fire-Resistance-Rated, Horizontal Assembly, and Smoke Barrier Penetrations: Maintain indicated fire or smoke rating of floors at pipe penetrations. Seal pipe penetrations with fire- and smoke-stop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

- B. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal-system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.

3.4 SLEEVE-SEAL-FITTING INSTALLATION

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

3.5 FIELD QUALITY CONTROL

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

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: Steel pipe sleeves.
 - 2. Exterior Concrete Walls Below Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
 - 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs Above Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.
5. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 DEFINITIONS

- A. Existing Piping to Remain: Existing piping that is not to be removed and that is not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 1. BrassCraft Manufacturing Co.; a Masco company.
 2. Dearborn Brass.
 3. Approved.

2.2 ESCUTCHEONS

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

- C. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.
- D. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished, chrome-plated finish and spring-clip fasteners.
- E. One-Piece, Stamped-Steel Type: With polished, chrome-plated finish and spring-clip fasteners.
- F. Split-Plate, Stamped-Steel Type: With polished, chrome-plated finish; concealed and exposed-rivet hinge; and spring-clip fasteners.

2.3 FLOOR PLATES

- A. Split Floor Plates: Steel with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

3.2 FIELD QUALITY CONTROL

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

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BID AND PERMIT SET

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Light-activated thermometers.
 - 2. Dial-type pressure gages.
 - 3. Gage attachments.
 - 4. Flowmeters.

- B. Related Requirements:

- 1. Section 231123 "Facility Natural-Gas Piping" for gas meters.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings:

- 1. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of meter and gage.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 LIGHT-ACTIVATED THERMOMETERS

A. Direct-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flo Fab Inc.
 - b. REOTEMP Instrument Corporation.
 - c. Trerice, H. O. Co.
 - d. Weiss Instruments, Inc.
 - e. WIKA Instrument Corporation.
 - f. Winters Instruments - U.S.
2. Case: Metal; 9-inch nominal size unless otherwise indicated.
3. Scale(s): Deg F and deg C.
4. Case Form: Adjustable angle.
5. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
6. Stem: Aluminum and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
7. Display: Digital.
8. Accuracy: Plus or minus 2 deg F.

B. Remote-Mounted, Light-Activated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Miljoco Corporation.
 - b. Weiss Instruments, Inc.
 - c. Winters Instruments - U.S.
2. Case: Plastic, for wall mounting.
3. Scale(s): Deg F and deg C.
4. Sensor: Bulb and thermister wire.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.
5. Display: Digital.
6. Accuracy: Plus or minus 2 deg F.

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.3 DIAL-TYPE PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ametek U.S. Gauge.
 - b. Ashcroft Inc.
 - c. KOBOLD Instruments, Inc.
 - d. Terrice, H. O. Co.
 - e. Weiss Instruments, Inc.
 - 2. Standard: ASME B40.100.
 - 3. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
 - 4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 5. Pressure Connection: Brass, with NPS 1/4, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 6. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
 - 8. Pointer: Dark-colored metal.
 - 9. Window: Glass or plastic.
 - 10. Ring: Metal or Plastic.
 - 11. Accuracy: Grade B, plus or minus 2 percent of middle half of scale range.

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. Siphons: Loop-shaped section of brass pipe with NPS 1/4 pipe threads.
- C. Valves: Brass or stainless-steel needle, with NPS 1/4, ASME B1.20.1 pipe threads.

2.5 FLOWMETERS

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

- a. ABB.
 - b. Eastech Flow Controls.
 - c. Ebtron.
 - d. EMCO Flow Systems.
2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Inline type; for installing between pipe flanges and measuring flow directly in gallons per minute.
 - a. Design: Flow obstruction device, vortex-measurement type for liquids.
 - b. Construction: Stainless-steel body, with integral transmitter and direct-reading scale.
 - c. Minimum Pressure Rating: 1000 psig.
 - d. Minimum Temperature Rating: 500 deg F.
 - e. Integral Transformer: For low-voltage power operation.
5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus or minus 0.25 percent for liquids.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending a minimum of 2 inches into fluid and in vertical position in piping tees.
- B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.
- G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.
- H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.
- I. Install remote-mounted pressure gages on panel.

- J. Install valve and snubber in piping for each pressure gage for fluids (except steam).
- K. Install valve and syphon fitting in piping for each pressure gage for steam.
- L. Install test plugs in piping tees.
- M. Install flow indicators in piping systems in accessible positions for easy viewing.
- N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.
- O. Install flowmeter elements in accessible positions in piping systems.
- P. Install wafer-orifice flowmeter elements between pipe flanges.
- Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.
- R. Install permanent indicators on walls or brackets in accessible and readable positions.
- S. Install connection fittings in accessible locations for attachment to portable indicators.
- T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.
- U. Install thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler.
 - 3. Inlet and outlet of each hydronic coil in air-handling units.
- V. Install pressure gages in the following locations:
 - 1. Discharge of each pressure-reducing valve.
 - 2. Suction and discharge of each pump.

3.2 CONNECTIONS

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

3.3 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.

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

3.4 THERMOMETER SCHEDULE

- A. Thermometers at inlet and outlet of each hydronic zone, hydronic boiler, and hydronic coil in air-handling units, shall be the following:
 - 1. Direct-mounted, light-activated type.
- B. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Chilled-Water Piping: 0 to 110 deg F.
- B. Scale Range for Heating, Hot-Water Piping: 30 to 240 deg F.
- C. Scale Range for Air Ducts: 0 to 110 deg F.

3.6 PRESSURE-GAGE SCHEDULE

- A. Pressure gages at discharge of each pressure-reducing valve shall be the following:
 - 1. Liquid-filled, direct-mounted, metal case.
- B. Pressure gages at suction and discharge of each pump shall be the following:
 - 1. Liquid-filled, direct-mounted, metal case.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Heating, Hot-Water Piping: 0 to 100 psi.

3.8 FLOWMETER SCHEDULE

- A. Flowmeters for Heating, Hot-Water Piping: Vortex-shedding type.

SECTION 230523.12 - BALL VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Brass ball valves.
 - 2. Bronze ball valves.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.5 for flanges on steel valves.
 - 4. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 5. ASME B16.18 for solder-joint connections.
 - 6. ASME B31.1 for power piping valves.
 - 7. ASME B31.9 for building services piping valves.
- C. 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.
- D. Refer to HVAC valve schedule articles for applications of valves.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 4 and larger.
 - 2. Handlever: For quarter-turn valves smaller than NPS 4.
- H. Valves in Insulated Piping:
 - 1. Include 2-inch stem extensions.
 - 2. Extended operating handle of nonthermal-conductive material, and protective sleeves that allow operation of valves without breaking the vapor seals or disturbing insulation.
 - 3. Memory stops that are fully adjustable after insulation is applied.
- I. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

- A. Bronze Ball Valves, Two-Piece with Full Port and Bronze or Brass Trim, Threaded Ends:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. Red-White Valve Corp.
- 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Bronze.
 - i. Ball: Chrome-plated brass.
 - j. Port: Full.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- B. Select valves with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option or press-end option is indicated in valve schedules below.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.4 HEATING-WATER VALVE SCHEDULE

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

END OF SECTION 230523.12

SECTION 230523.13 - BUTTERFLY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Iron, single-flange butterfly valves.
2. Iron, grooved-end butterfly valves.
3. High-performance butterfly valves.
4. Chainwheels.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 1. Protect internal parts against rust and corrosion.
 2. Protect threads, flange faces, grooves, and weld ends.
 3. Set butterfly valves closed or slightly open.
- B. Use the following precautions during storage:
 1. Maintain valve end protection.

2. Store valves indoors and maintain at higher-than-ambient-dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- 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. ASME Compliance:
 1. ASME B16.1 for flanges on iron valves.
 2. ASME B16.5 for pipe flanges and flanged fittings, NPS 1/2 through NPS 24.
 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 4. ASME B31.1 for power piping valves.
 5. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valve Actuator Types:
 1. Gear Actuator: For valves NPS 8 and larger.
 2. Handlever: For valves NPS 6 and smaller.
 3. Chainwheel: Device for attachment to gear, stem, or other actuator of size and with chain for mounting height, according to "Valve Installation" Article.
- G. Valves in Insulated Piping: With 2-inch stem extensions with extended necks.

2.2 IRON, SINGLE-FLANGE BUTTERFLY VALVES

- A. Iron, Single-Flange Butterfly Valves with Ductile-Iron Disc:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Center Line.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.

- e. Mueller Steam Specialty; a division of SPX Corporation.
 - f. NIBCO INC.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
- a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 150 psig.
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A126, cast iron or ASTM A536, ductile iron.
 - e. Seat: EPDM.
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Nickel-plated ductile iron.

2.3 CHAINWHEELS

- A. Description: Valve actuation assembly with sprocket rim, chain guides, chain.
- 1. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
 - 2. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.

- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.
- F. Install valve tags. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

3.3 ADJUSTING

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

3.4 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Larger:
 - 1. Iron, Single-Flange Butterfly Valves, NPS 3 and larger: Ductile-iron disc, 200 CWP, and EPDM seat.

END OF SECTION 230523.13

SECTION 230523.14 - CHECK VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Iron swing check valves.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. EPDM: Ethylene propylene copolymer rubber.
- C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- D. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. 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. ASME Compliance:
 - 1. ASME B1.20.1 for threads for threaded-end valves.
 - 2. ASME B16.1 for flanges on iron valves.
 - 3. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 4. ASME B16.18 for solder joint.
 - 5. ASME B31.1 for power piping valves.
 - 6. ASME B31.9 for building services piping valves.
- C. AWWA Compliance: Comply with AWWA C606 for grooved-end connections.
- D. 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.
- E. Valve Pressure-Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- F. Valve Sizes: Same as upstream piping unless otherwise indicated.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 IRON SWING CHECK VALVES

- A. Iron Swing Check Valves with Metal Seats, Class 125:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Red-White Valve Corporation.
 - 2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A126, gray iron with bolted bonnet.
 - f. Ends: Flanged.

- g. Trim: Bronze.
- h. Gasket: Asbestos free.

2.3 BRONZE SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Red-White Valve Corp.
2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.

- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
- F. Install valve tags. Comply with requirements for valve tags and schedules in Section 230553 "Identification for HVAC Piping and Equipment."

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Pump-Discharge Check Valves:
 - a. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.
- B. If valves with specified SWP classes or CWP ratings are unavailable, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
 - 1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules.
 - 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 - 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules.
 - 6. For Steel Piping, NPS 5 and Larger: Flanged ends.
 - 7. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 - 2. Bronze swing check valves with bronze disc, Class 125.

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

1. NPS 2-1/2 to NPS 4: Iron valves may be provided with threaded ends instead of flanged ends.
2. Iron swing check valves with metal seats, Class 125.

END OF SECTION 230523.14

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal hanger-shield inserts.
5. Fastener systems.
6. Equipment supports.

B. Related Requirements:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 220516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
3. Section 220548 "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 ACTION SUBMITTALS

- A. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Equipment supports.

- B. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Include design calculations for designing trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Structural-Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M.
- B. Pipe Welding Qualifications: Qualify procedures and operators according to 2015 ASME Boiler and Pressure Vessel Code, Section IX.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design trapeze pipe hangers and equipment supports.
- 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, 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.
 - 3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

2.2 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized, hot-dip galvanized, or electro-galvanized.
 - 3. Nonmetallic Coatings: Plastic coated or epoxy powder coated.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Stainless-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Thomas & Betts Corporation; A Member of the ABB Group.
 - c. Unistrut; Part of Atkore International.
2. Description: Shop- or field-fabricated pipe-support assembly, made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
3. Standard: Comply with MFMA-4, factory-fabricated components for field assembly.
4. Channels: Continuous slotted carbon-steel channel with inturned lips.
5. Channel Width: Selected for applicable load criteria.
6. Channel Nuts: Formed or stamped nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
7. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.5 THERMAL HANGER-SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carpenter & Paterson, Inc.
 2. ERICO International Corporation.
 3. Pipe Shields Inc.
 4. Rilco Manufacturing Co., Inc.
 5. Value Engineered Products, Inc.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig minimum compressive strength.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

- A. 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Empire Tool and Manufacturing Co., Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - e. MKT Fastening, LLC.
 - 2. Indoor Applications: Zinc-coated steel.
 - 3. Outdoor Applications: Stainless steel.

2.7 EQUIPMENT SUPPORTS

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

2.8 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/C 1107M, 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 078413 "Penetration Firestopping" for firestopping materials and installation, for penetrations through fire-rated walls, ceilings, and assemblies.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

3.2 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-58. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-58. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size, or install intermediate supports for smaller-diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-58. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- E. Thermal Hanger-Shield Installation: Install in pipe hanger or shield for insulated piping.
- F. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete, after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- G. Install hangers and supports complete with necessary attachments, 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 and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- J. Install lateral bracing with pipe hangers and supports to prevent swaying.

- K. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms, and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Install hangers and supports, so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- N. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating Above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating Below Ambient Air Temperature: Use thermal hanger-shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39 protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger-shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
 - 5. Pipes NPS 8 and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal Hanger Shields: Install with insulation of same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

3.4 METAL FABRICATIONS

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

3.5 ADJUSTING

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

3.6 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 099123 "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.

3.7 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finishes.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Use padded hangers for piping that is subject to scratching.
- 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 up to 1050 deg F pipes NPS 4 to NPS 24, 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 36, 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. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 - 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8.
 - 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 - 11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 - 12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 - 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
 17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30, from two rods if longitudinal movement caused by expansion and contraction occurs.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction occurs.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction occurs but vertical adjustment is unnecessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 if small horizontal movement caused by expansion and contraction occurs and vertical adjustment is unnecessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 if vertical and lateral adjustment during installation, in addition to expansion and contraction, is required.
- I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24.
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 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 of up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11 split pipe rings.
 4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- K. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable-Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- 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. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load, and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- N. Comply with MSS SP-58 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 mechanical-expansion anchors instead of building attachments where required in concrete construction.
- Q. Use pipe-positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS 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. Pipe-riser resilient supports.
2. Resilient pipe guides.
3. Restraint channel bracings.
4. Restraint cables.
5. Seismic-restraint accessories.
6. Mechanical anchor bolts.
7. Adhesive anchor bolts.

B. Related Requirements:

1. Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment" for devices for fire-suppression equipment and systems.
2. Section 230548 "Vibration and Seismic Controls for HVAC" for devices for HVAC equipment and systems.

1.3 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.
- C. OSHPD: Office of Statewide Health Planning & Development (for the State of California).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of vibration isolation device and seismic-restraint component required.

- a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
 3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.
- B. Shop Drawings:
 1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment.
- C. Delegated-Design Submittal: For each vibration isolation and seismic-restraint device.
 1. Include design calculations and details for selecting vibration isolators and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 2. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, due to seismic forces required to select vibration isolators, and due to seismic restraints.
 3. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system was examined for excessive stress and that none exists.
 4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
 - d. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of vibration isolation device installation and seismic bracing for plumbing piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- B. Qualification Data: For professional engineer and testing agency.

- C. Welding certificates.
- D. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7 and that is acceptable to authorities having jurisdiction.
- B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- C. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are unavailable, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: See S0.1.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: See S0.1.
 - a. Component Importance Factor: 1.0.
 - b. Component Response Modification Factor: Refer to ASCE Standard 7-10, Chapter 13.
 - c. Component Amplification Factor: Refer to ASCE Standard 7-10, Chapter 13.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): See S0.1.
 - 4. Design Spectral Response Acceleration at 1.0-Second Period: See S0.1.
 - 5. Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they are subjected.

2.2 RESTRAINT CHANNEL BRACINGS

- A. Description: MFMA-4, shop- or field-fabricated bracing assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; rated in tension, compression, and torsion forces.

2.3 RESTRAINT CABLES

- A. Restraint Cables: ASTM A 603 galvanized-steel cables. End connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; with a minimum of two clamping bolts for cable engagement.

2.4 SEISMIC-RESTRAINT ACCESSORIES

- A. Hanger-Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.
- B. Hinged and Swivel Brace Attachments: Multifunctional steel connectors for attaching hangers to rigid channel bracings.
- C. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
- D. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
- E. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

2.5 MECHANICAL ANCHOR BOLTS

- A. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Hanger-Rod Stiffeners: Install hanger-rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength is adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete."
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.
- C. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- D. Equipment Restraints:
 - 1. Install seismic snubbers on plumbing equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
 - 2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
 - 3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- E. Piping Restraints:
 - 1. Comply with requirements in MSS SP-127.
 - 2. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 - 3. Brace a change of direction longer than 12 feet.
- F. Install cables so they do not bend across edges of adjacent equipment or building structure.

- G. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction that provides required submittals for component.
- H. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- I. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
- J. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- K. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 221116 "Domestic Water Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after piping system is at operating weight.
- B. Adjust limit stops on restrained-spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

END OF SECTION 220548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

1.3 SUBMITTAL

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch, Stainless steel, 0.025-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.
- D. Dual Point Connection Equipment: Label "MORE THAN ONE DISCONNECT REQUIRED TO DE-ENERGIZE EQUIPMENT" in easily viewable location on RTU's listed as connected to emergency power.

2.2 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pre-Tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.3 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- D. 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.
- E. Fasteners: Stainless-steel rivets or self-tapping screws.
- F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions or as separate unit on each duct label to indicate flow direction.
 2. Lettering Size: At least 1-1/2 inches high.
- H. 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 S-hook.
- I. Valve Schedules: For each piping system, on 24x36 bond paper, framed with glazed cover. 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.
- J. A copy of the 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. All air and piping systems shown on plans shall be labeled.
- B. Install or permanently fasten labels on each major item of mechanical equipment.
- C. Locate equipment labels where accessible and visible.
- D. Provide P-touch labels on ceiling tiles to indicate location of equipment above ceiling-such as VAV boxes, shut-off valves for heating, air and plumbing piping, and all other equipment that are accessed for maintenance.

3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting."
- B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs 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. Reduce intervals to 25 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

C. Pipe Label Color Schedule:

1. Heating Water Piping:
 - a. Background Color: White.
 - b. Letter Color: Black.
2. Geothermal Water Piping:
 - a. Background Color: White.
 - b. Letter Color: Black
3. Refrigerant Piping:
 - a. Background Color: Black.
 - b. Letter Color: White.

3.4 DUCT LABEL INSTALLATION

- A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
 1. Blue: For cold-air supply ducts.
 2. Yellow: For hot-air supply ducts.
 3. Green: For exhaust, return.
- B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

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. All valves in the building shall be tagged and identified.
- B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
 - a. Heating Hot Water: 1-1/2 inches round.
2. Valve-Tag Color:
 - a. Heating Hot Water: Natural.
3. Letter Color:
 - a. Heating Hot Water: Red.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

- 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
- 2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
- 3. Balancing Domestic Piping Systems:
 - a. Constant-flow domestic hot water circulation systems.
- 4. Flow meter verification
 - a. Variable flow hydronic systems.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TABB: Testing, Adjusting, and Balancing Bureau.
- E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- 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. 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.
- D. Certified TAB reports.
- E. Sample report forms.
- F. 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 Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.
- B. TAB Conference: Meet with Architect on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
 - 1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. Certify TAB field data reports and perform the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.

2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

- D. TAB Report Forms: Use standard TAB contractor's forms approved by Architect.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.6 PROJECT CONDITIONS

- A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.
- B. 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. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. All air and hydronic systems shall be tested, adjusted and balanced.
- C. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
- 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 used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- G. 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.
- H. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- I. Examine test reports specified in individual system and equipment Sections.
- J. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
- L. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- O. Examine system pumps to ensure absence of entrained air in the suction piping.
- P. Examine operating safety interlocks and controls on HVAC equipment.
- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system-readiness checks and prepare reports. Verify the following:
 - 1. Permanent electrical-power wiring is complete.
 - 2. Hydronic systems are filled, clean, and free of air.
 - 3. Automatic temperature-control systems are operational.
 - 4. Equipment and duct access doors are securely closed.
 - 5. Balance, smoke, and fire dampers are open.
 - 6. Isolating and balancing valves are open and control valves are operational.
 - 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 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.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2, "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."
 - 3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "HVAC Insulation."
- C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts."

3.5 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. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
 - 2. Measure fan static pressures as follows to determine actual static pressure:
 - a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
 - b. Measure static pressure directly at the fan outlet or through the flexible connection.
 - c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
 - d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
 - 3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
 - a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
 5. 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.
 6. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 23 Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.
1. Measure airflow of sub-main and branch ducts.
 - a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
 2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
 3. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.
- C. Measure air outlets and inlets without making adjustments.
1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
- D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
 - 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - 3. Measure total system airflow. Adjust to within indicated airflow.
 - 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
 - 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 - 6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 - 8. Record final fan-performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.

- C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
1. Open all manual valves for maximum flow.
 2. Check liquid level in expansion tank.
 3. Check makeup water-station pressure gage for adequate pressure for highest vent.
 4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 6. Set system controls so automatic valves are wide open to heat exchangers.
 7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HEAT EXCHANGERS

- A. Measure water flow through all circuits.
- B. Adjust water flow to within specified tolerances.
- C. Measure inlet and outlet water temperatures.
- D. Measure inlet steam pressure.
- E. Check settings and operation of safety and relief valves. Record settings.

3.9 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. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.

B. Measure entering- and leaving-air temperatures.

C. Record compressor data.

3.11 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

3.12 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.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

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 and at each incremental stage.
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. Air pressure drop.
4. 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.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

E. Measure and record the following data for each hydronic flow meter:

1. Actual flow rate vs indicated flow rate.

3.13 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - 2. Air Outlets and Inlets: Plus or minus 5 percent.
 - 3. Heating-Water Flow Rate: Plus or minus 10 percent.
- B. Set domestic hot water recirculation system water flow rates to maintain measurable water flow through each branch.

3.14 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors. Include significant testing notes and comments where airflows and water flows or other recorded data outputs are not within the AABC, NEBB and/or spec standard tolerances from design numbers. Describe issues such that they can communicate whether the design, installation, access testing conditions, or other factors can be identified to the project team for response.

3.15 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 - d. Summarized of testing notes and comments where airflows, water flows, or recorded outputs are not within AABC, NEBB and/or spec standard tolerances from design numbers.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:

1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

E. 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 (mm), and bore.
- i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
- j. Number, make, and size of belts.
- k. Number, type, and size of filters.

2. Motor Data:

- a. Motor make, and frame type and size.
- b. Horsepower and rpm.
- c. Volts, phase, and hertz.
- d. Full-load amperage and service factor.
- e. Sheave make, size in inches (mm), and bore.
- f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

- a. Total air flow rate in cfm (L/s).
- b. Total system static pressure in inches wg (Pa).
- c. Fan rpm.
- d. Discharge static pressure in inches wg (Pa).
- e. Filter static-pressure differential in inches wg (Pa).
- f. Preheat-coil static-pressure differential in inches wg (Pa).
- g. Cooling-coil static-pressure differential in inches wg (Pa).
- h. Heating-coil static-pressure differential in inches wg (Pa).
- i. Outdoor airflow in cfm (L/s).
- j. Return airflow in cfm (L/s).
- k. Outdoor-air damper position.
- l. Return-air damper position.
- m. Vortex damper position.

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 (mm) o.c.

- f. Make and model number.
 - g. Face area in sq. ft. (sq. m).
 - h. Tube size in NPS (DN).
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
- 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm (L/s).
 - b. Average face velocity in fpm (m/s).
 - c. Air pressure drop in inches wg (Pa).
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F (deg C).
 - e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
 - f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
 - h. Water flow rate in gpm (L/s).
 - i. Water pressure differential in feet of head or psig (kPa).
 - j. Entering-water temperature in deg F (deg C).
 - k. Leaving-water temperature in deg F (deg C).
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig (kPa).
 - n. Refrigerant suction temperature in deg F (deg C).
 - o. Inlet steam pressure in psig (kPa).
- G. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup
- H. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
 - 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated air flow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual air flow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).
- 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. (sq. m).
 - 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary air flow rate as needed in cfm (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final air flow rate in cfm (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).
- 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. Air flow rate in cfm (L/s).
 - b. Entering-water temperature in deg F (deg C).
 - c. Leaving-water temperature in deg F (deg C).
 - d. Water pressure drop in feet of head or psig (kPa).
 - e. Entering-air temperature in deg F (deg C).
 - f. Leaving-air temperature in deg F (deg C).
- K. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model number and serial number.
 - f. Water flow rate in gpm (L/s).
 - g. Water pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump rpm.

- j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
2. Test Data (Indicated and Actual Values):
- a. Static head in feet of head or psig (kPa).
 - b. Pump shutoff pressure in feet of head or psig (kPa).
 - c. Actual impeller size in inches (mm).
 - d. Full-open flow rate in gpm (L/s).
 - e. Full-open pressure in feet of head or psig (kPa).
 - f. Final discharge pressure in feet of head or psig (kPa).
 - g. Final suction pressure in feet of head or psig (kPa).
 - h. Final total pressure in feet of head or psig (kPa).
 - i. Final water flow rate in gpm (L/s).
 - j. Voltage at each connection.
 - k. Amperage for each phase.

L. Instrument Calibration Reports:

1. Report Data:
- a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.16 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
- 2. Check the following for each system:
 - a. Measure airflow of at least 20 percent of air outlets.
 - b. Measure water flow of at least 10 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect.
3. Architect 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.
4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.17 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - 4. Indoor, concealed oven and warewash exhaust.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
- B. Related Sections:
 - 1. Section 230716 "HVAC Equipment Insulation."
 - 2. Section 230719 "HVAC Piping Insulation."
 - 3. Section 233113 "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- 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.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 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 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- 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. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cell-U-Foam Corporation; Ultra-CUF.
 - b. Pittsburgh Corning Corporation; Foamglass Super K.
 - c. Or approved equal
 2. Block Insulation: ASTM C 552, Type I.
 3. Special-Shaped Insulation: ASTM C 552, Type III.
- E. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
 - d. Or approved equal
- 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.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- G. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.

- c. Knauf Insulation.
- d. Manson Insulation Inc.
- e. Owens Corning.

2.2 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. CertainTeed Corporation.
 - c. Johns Manville; a Berkshire Hathaway company.
 - d. Nelson Firestop; a brand of Emerson Industrial Automation.
 - e. Thermal Ceramics.
 - f. Unifrax Corporation.

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. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 - 1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; CP-96.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-33.
 - c. Or approved equal
- C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. K-Flex USA.

2. Adhesives shall have a VOC content of 50 g/L or less.
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.
- E. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. Adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- F. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Dow Corning Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. P.I.C. Plastics, Inc.
 - d. Red Devil, Inc.; Celulon Ultra Clear.
 - e. Speedline Corporation.

2.4 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Marathon Industries, Inc.; 225.
 - d. Mon-Eco Industries, Inc.
 - 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.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Or approved equal
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: White.

2.5 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and

with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

- a. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
6. PVDC Jacket for Outdoor Applications: 6-mil thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - a. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 - a. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.6 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: Color-code jackets based on system. Color as selected by Architect.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 5. Factory-fabricated tank heads and tank side panels.
- D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metals Corporation; Surefit.
 - c. RPR Products, Inc.; Insul-Mate.
 2. Sheet and roll stock ready for shop or field sizing.
 3. Finish and thickness are indicated in field-applied jacket schedules.
 4. Moisture Barrier for Indoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
 5. Moisture Barrier for Outdoor Applications: 3-mil thick, heat-bonded polyethylene and kraft paper.
 6. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Self-Adhesive Outdoor Jacket: 60-mil thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a

rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.

1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Polyguard; Alumaguard 60.
 - b. Or approved equal.

- F. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - b. Or approved equal

2.7 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

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

- a. Avery Denison Corporation, Specialty Tapes Division; Fasson 0555.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.
- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
 2. Width: 2 inches.
 3. Thickness: 3.7 mils.
 4. Adhesion: 100 ounces force/inch in width.
 5. Elongation: 5 percent.
 6. Tensile Strength: 34 lbf/inch in width.

2.8 SECUREMENTS

A. 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.

- d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
 3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.

- 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 - 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-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.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
 - C. Wire: 0.062-inch soft-annealed, galvanized steel.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. C & F Wire.
 - b. Childers Products.
 - c. PABCO Metals Corporation.
 - d. RPR Products, Inc.
- 2.9 CORNER ANGLES
- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
 - B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

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.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that applies to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- 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. Duct liner is not acceptable method; all insulation to be externally wrapped.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation,

- install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
- 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
- 1. Comply with requirements in Section 078413 "Penetration Firestopping."
- E. Insulation Installation at Floor Penetrations:
- 1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 - 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."
- 3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION
- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 3.6 INSTALLATION OF MINERAL-FIBER INSULATION
- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. 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 manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.9 FINISHES

- A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
 - 4. Indoor, concealed oven and warewash exhaust.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
 - 7. Outdoor, exposed supply and return.
- B. Items Not Insulated:
 - 1. Factory-insulated flexible ducts.
 - 2. Flexible connectors.
 - 3. Vibration-control devices.
 - 4. Factory-insulated access panels and doors.

3.12 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Indoor:

DUCT TYPE	DUCT LOCATION	INSULATION R VALUE	INSULATION TYPE	OTHER REQUIREMENTS
Supply, Makeup Air	On exterior of building, on roof, in attic, in enclosed ceiling space, in walls.	R-7	Mineral fiber blanket.	Approved weather proof barrier.
Outside/Combustion Air Intake	Inside building.	R-7	Mineral fiber blanket or rigid fiber board.	R-21 between intake and motorized damper.
Type I & Type II Commercial Kitchen Hood Exhaust Duct	All		Fire rated blanket.	2 hour rating.

3.13 FIELD-APPLIED JACKET SCHEDULE

A. Indoor:

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.

B. Outdoor

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. Ducts, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches: Aluminum, Smooth: 0.020 inch thick
3. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches: Painted Aluminum, Smooth 2-1/2-Inch Deep Corrugations: 0.040 inch thick.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Heating, hot-water pumps.
2. Expansion/compression tanks.
3. Air separators.

- B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230719 "HVAC Piping Insulation."

1.3 REFERENCES

- A. Oregon State Energy Code – 2014 Edition and as amended by local authority having jurisdiction.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 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.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with equipment Installer for equipment insulation application.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- 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. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cell-U-Foam Corporation, Ultra-CUF.
 - b. Pittsburgh Corning Corporation.
 - c. Or approved equal.

2. Block Insulation: ASTM C 552, Type I.
 3. Special-Shaped Insulation: ASTM C 552, Type III.
- E. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
 - d. Or approved equal.
- 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.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- G. Mineral-Fiber, Preformed Pipe Insulation:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Fibrex Insulation Inc.; Coreplus 1200.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. 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. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h

x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Cellular-Glass, Phenolic, Polyisocyanurate and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Or approved equal.
- C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. K-Flex USA.
 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers," including 2004 Addenda.
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Marathon Industries.
 - d. Mon-Eco Industries, Inc.
- E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 1. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers," including 2004 Addenda.
- F. PVC Jacket Adhesive: Compatible with PVC jacket.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Dow Corning Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. P.I.C. Plastics, Inc.
 - d. Red Devil, Inc.; Celulon Ultra Clear.
 - e. Speedline Corporation.

2.3 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.

- b. Foster Brand; H. B. Fuller Construction Products.
 - c. Marathon Industries.
 - d. Mon-Eco Industries, Inc.
 - 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.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Or approved equal.
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: White.

2.4 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.

6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.5 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Johns Manville; a Berkshire Hathaway company.
 - b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: Color-code jackets based on system. Color as selected by Architect.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate:
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 5. Factory-fabricated tank heads and tank side panels.
- D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metal Corporation; Surefit.
 - c. RPR Products, Inc.
 2. Sheet and roll stock ready for shop or field sizing.
 3. Finish and thickness are indicated in field-applied jacket schedules.
 4. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
 5. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
 6. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Polyguard Products, Inc.
 - b. Or approved equal.
- F. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - b. Or approved equal.

2.6 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Speciality Tapes Division; Fasson 0555.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

- C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.7 SECUREMENTS

A. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.

- b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- 3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
- 4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- 5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-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.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Gemco.

2) Midwest Fasteners, Inc.

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

C. Wire: 0.062-inch soft-annealed, galvanized steel.

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

- a. C & F Wire.
- b. Childers Products.
- c. PABCO Metal Corporation.
- d. RPR Products, Inc.

2.8 CORNER ANGLES

A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- J. 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. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
- K. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- L. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- M. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- N. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.3 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

- A. Mineral-Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches 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.

3.4 FIELD-APPLIED JACKET INSTALLATION

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

3.5 FINISHES

- A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.7 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment that is not factory insulated.

- C. Heating-hot-water pump insulation shall be one of the following:
 - 1. Cellular Glass: 3 inches thick.
 - 2. Mineral-Fiber Board: 2 inches thick and 2-lb/cu. ft. nominal density.
- D. Heating-hot-water expansion/compression tank insulation:
 - 1. Mineral-Fiber Pipe and Tank: 2 inches thick.
- E. Heating-hot-water air-separator insulation:
 - 1. Mineral-Fiber Pipe and Tank: 2 inches thick.

3.8 FIELD-APPLIED JACKET SCHEDULE

- A. Indoor:
 - 1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - 2. If more than one material is listed, selection from materials listed is Contractor's option.
 - 3. Equipment, Exposed, Aluminum: 0.024 inch thick.
- B. Outdoor:
 - 1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
 - 2. If more than one material is listed, selection from materials listed is Contractor's option.
 - 3. Equipment, Exposed, Aluminum: 0.024 inch thick.

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors.
 - 2. Heating hot-water piping, indoors and outdoors.
 - 3. Refrigerant suction and hot-gas piping, indoors and outdoors.
- B. Related Sections:
 - 1. Section 230713 "Duct Insulation."
 - 2. Section 230716 "HVAC Equipment Insulation."

1.3 REFERENCES

- A. Oregon State Energy Code – 2014 Edition and as amended by local authority having jurisdiction.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 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.

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- 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. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, provide one of the following available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Cell-U-Foam Corporation; Ultra-CUF.
 - b. Pittsburgh Corning Corporation; Foamglass Super K.
 - c. Or approved equal
 2. Block Insulation: ASTM C 552, Type I.
 3. Special-Shaped Insulation: ASTM C 552, Type III.
- A. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
 - d. Or approved equal
- B. 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.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.
- C. Mineral-Fiber, Preformed Pipe Insulation:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Fibrex Insulation Inc.; Coreplus 1200.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. 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. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

- D. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 - d. Manson Insulation Inc.
 - e. Owens Corning.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Cellular-Glass, Phenolic, Polyisocyanurate and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Or approved equal.
- C. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Aeroflex USA, Inc.
 - b. Armacell LLC.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. K-Flex USA.
 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of

Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers,” including 2004 Addenda.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Marathon Industries.
 - d. Mon-Eco Industries, Inc.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Eagle Bridges - Marathon Industries.
 - c. Foster Brand; H. B. Fuller Construction Products.
 - d. Mon-Eco Industries, Inc.
2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers,” including 2004 Addenda.

F. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Dow Corning Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. P.I.C. Plastics, Inc.
 - d. Red Devil, Inc.; Celulon Ultra Clear.
 - e. Speedline Corporation.

2.3 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Foster Brand; H. B. Fuller Construction Products.
 - c. Marathon Industries.
 - d. Mon-Eco Industries, Inc.
 - 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.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Brand; H. B. Fuller Construction Products.
 - b. Or approved equal.
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: White.

2.4 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
6. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
7. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - 2) Or approved equal.
8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.5 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Johns Manville; a Berkshire Hathaway company.

- b. P.I.C. Plastics, Inc.
 - c. Proto Corporation.
 - d. Speedline Corporation.
 2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: Color-code jackets based on system. Color as selected by Architect.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- D. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metal Corporation; Surefit.
 - c. RPR Products, Inc.
 2. Sheet and roll stock ready for shop or field sizing.
 3. Finish and thickness are indicated in field-applied jacket schedules.
 4. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
 5. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
 6. Factory-Fabricated Fitting Covers:
 - a. Same material, finish, and thickness as jacket.
 - b. Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - c. Tee covers.
 - d. Flange and union covers.
 - e. End caps.
 - f. Beveled collars.
 - g. Valve covers.
 - h. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- E. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a cross-laminated polyethylene film covered with white aluminum-foil facing.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Polyguard Products, Inc.

- b. Or approved equal.

F. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Dow Chemical Company; Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.
 - b. Or approved equal.

2.6 TAPES

A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
- 2. Width: 3 inches.
- 3. Thickness: 6.5 mils.
- 4. Adhesion: 90 ounces force/inch in width.
- 5. Elongation: 2 percent.
- 6. Tensile Strength: 40 lbf/inch in width.
- 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Speciality Tapes Division; Fasson 0555.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
- 2. Width: 2 inches.
- 3. Thickness: 6 mils.
- 4. Adhesion: 64 ounces force/inch in width.

5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division.
 - b. Compac Corporation.
 - c. Ideal Tape Co., Inc., an American Biltrite Company.
 - d. Venture Tape.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

2.7 SECUREMENTS

A. Insulation Pins and Hangers:

1. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
2. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.

- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
 - b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
 - c. Spindle: Nylon, 0.106-inch-diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
 - d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
3. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place.
- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - c. Spindle: Copper- or zinc-coated, low-carbon steel, fully annealed, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
 - d. Adhesive-backed base with a peel-off protective cover.
4. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) AGM Industries, Inc.
 - 2) Gemco.
 - 3) Midwest Fasteners, Inc.
 - 4) Nelson Stud Welding.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
5. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-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.

- a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Gemco.
 - 2) Midwest Fasteners, Inc.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch-wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, galvanized steel.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. C & F Wire.
 - b. Childers Products.
 - c. PABCO Metal Corporation.
 - d. RPR Products, Inc.

2.8 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.
- B. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. 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 4 inches o.c.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
- 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. Manholes.
5. Handholes.
6. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Floor Penetrations:
 1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.

2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Insulation Installation on Pipe Flanges:
 1. Install pipe insulation to outer diameter of pipe flange.
 2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
 3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
 4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- C. Insulation Installation on Pipe Fittings and Elbows:
 1. Install mitered sections of pipe insulation.
 2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- D. Insulation Installation on Valves and Pipe Specialties:
 1. Install preformed valve covers manufactured of same material as pipe insulation when available.
 2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
 3. Install insulation to flanges as specified for flange insulation application.
 4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.6 INSTALLATION OF MINERAL-FIBER 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.

3.7 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.8 FINISHES

- A. Pipe Insulation with ASJ, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."
1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.
- B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.9 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform tests and inspections.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 PIPING INSULATION SCHEDULE, GENERAL

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

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

3.11 PIPING INSULATION SCHEDULE

A. Thickness:

MINIMUM PIPE INSULATION THICKNESS (INCHES) ^{a,b,c}							
FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (INCHES)				
	CONDUCTIVITY (BTU-IN/(H·FT ² ·°F))	MEAN RATING TEMPERATURE, °F	<1	1 to <1.5	1.5 TO <4	4 TO <8	8 >
>350	0.32-0.34	250	4.5	5.0	5.0	5.0	5.0
251-350	0.29-0.32	200	3.0	4.0	4.5	4.5	4.5
201-250	0.27-0.30	150	2.5	2.5	2.5	3.0	3.0
141-200	0.25-0.29	125	1.5	1.5	2.0	2.0	2.0
105-140	0.21-0.28	100	1.0	1.0	1.5	1.5	1.5
40-60	0.21-0.27	75	0.5	0.5	1.0	1.0	1.0
<40	0.20-0.26	50	0.5	1.0	1.0	1.0	1.5

a. FOR PIPING SMALL THAN 1.5 INCH AND LOCATED IN PARTITIONS WITHIN CONDITIONED SPACES, REDUCTION OF THESE THICKNESSES BY 1 INCH SHALL BE PERMITTED (BEFORE THICKNESS ADJUSTMENT REQUIRED IN FOOTNOTE b) BUT NOT TO A THICKNESS LESS THAN 1 INCH.

b. FOR INSULATION OUTSIDE THE STATED CONDUCTIVITY RANGE, THE MINIMUM THICKNESS (T) SHALL BE DETERMINED AS FOLLOWS:

$$T = r \{ (1 + t/r)^{K/k} - 1 \}$$

WHERE:

T = MINIMUM INSULATION THICKNESS

r = ACTUAL OUTSIDE RADIUS OF PIPE.

t = INSULATION LISTED IN TABLE ABOVE FOR APPLICABLE FLUID TEMPERATURE AND PIPE SIZE.

K = CONDUCTIVITY OF ALTERNATE MATERIAL AT MEAN RATING TEMPERATURE INDICATED FOR THE APPLICABLE FLUID TEMPERATURE (BTU*IN/H*FT²*°F) and

k = THE UPPER VALUE OF THE CONDUCTIVITY RANGE LISTED ABOVE FOR THE APPLICABLE FLUID TEMPERATURE.

c. FOR DIRECT-BURIED HEATING AND HOT WATER SYSTEM PIPING, REDUCTION OF THESE THICKNESSES BY 1.5 INCHES SHALL BE PERMITTED (BEFORE THICKNESS ADJUSTMENT REQUIRED IN FOOTNOTE B BUT NOT TO A THICKNESS LESS THAN 1 INCH.

B. Materials – Indoors:

1. Heating-Hot Supply and Return, NPS 1.25" and less, 105-140 Deg F: Mineral-Fiber, Preformed Pipe, Type I.
2. Heating-Hot- Supply and Return, NPS 1.5" and larger, 105-140 Deg F: Mineral-Fiber, Preformed Pipe, Type I.
3. Refrigerant Tubing and Piping: Flexible elastomeric.

4. Condensate and Equipment Drain Water (40-60°F): Mineral-Fiber, Preformed Pipe, Type I.

C. Materials – Outdoors Above Ground:

1. Refrigerant Piping: Flexible Elastomeric.

3.12 FIELD-APPLIED JACKET SCHEDULE

A. Indoor:

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Piping, exposed in Mechanical Room and elsewhere where exposed, up to 8'-0" A.F.F.: PVC: 30 mils thick.
4. Equipment, exposed, Aluminum, 0.024 inches thick.

B. Outdoor

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. Ducts up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches: Galvanized steel, 20 gauge.
3. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches: Galvanized steel, 18 gauge.
4. Piping, Exposed: Aluminum: 0.020 inches thick.

END OF SECTION 230719

SECTION 230800 – HVAC COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes general requirements that apply to implementation of commissioning of HVAC systems and components. It will assist operating staff training and familiarization with new systems. It will serve as a tool to reduce post-occupancy critical systems operational difficulty or failure. It will also be used to develop test protocol and record the associated test data to advance the building systems from a state of substantial completion to operation.
- B. All mechanical systems in the project shall perform in accordance with the design intent and the Owner's operational needs.
- C. The Commissioning Process Overview, applying to the HVAC systems and HVAC commissioning team members, can be found in specifications section 019113, General Commissioning Requirements.
- D. Systems to be commissioned:
 - 1. HVAC and mechanical system and all integral equipment controls. All HVAC systems shall be commissioned, including, but not limited to:
 - a. Building Controls
 - b. Boilers
 - c. VFD hydronic system pumps
 - d. Packaged rooftop units gas heat, dx cooling
 - e. VAV terminal units
 - f. Split system AC units
 - g. Makeup air units
 - h. Exhaust fans
 - i. Ceiling fans
 - j. Unit heaters
 - k. TAB

1.2 RESPONSIBILITIES

- A. Overview: The responsibilities of the HVAC commissioning team members in the commissioning process are summarized in specifications section 019113, General Commissioning Requirements.

1.3 SUBMITTALS

- A. Other Equipment and System Information.

1. When not included with the standard submittals, the Trade Subcontractors shall provide to the Commissioning Provider requested shop drawings, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures and control drawings. In addition, the manufacturer installation and checkout materials that are shipped inside the equipment and the field checkout forms to be used by the factory or field technicians shall be submitted to the Commissioning Provider. This documentation may be required prior to the normal O&M manual submittals.
- B. All equipment and system documentation requested by the Commissioning Provider shall be included by the Trade Subcontractors later in the O&M manuals.
- C. The Trade Subcontractors shall submit startup forms and procedures.

1.4 QUALITY ASSURANCE

- A. Test Equipment:
 1. All standard testing equipment required for the Trade Subcontractors to perform installation, start-up and initial checkout and required functional testing shall be provided by the Trade Subcontractors.
 2. Special tools and instruments, only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents shall be provided.
 3. Instrumentation will be provided by the Subcontractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.
 4. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.
 5. The Trade Subcontractors shall provide datalogging equipment for setting up and testing of cold rooms, clean room certification, fume hoods and lab room pressurization and equipment required to perform specified electrical equipment testing.
 6. Datalogging equipment required for testing equipment in support areas shall be provided and used by the Commissioning Provider.

1.5 COORDINATION

- A. Commissioning Team: The members of the commissioning team consist of the Commissioning Provider, the Owner/Owner Representative, the GC, the Architect and Design Engineers, the mechanical contractor, the testing adjusting and balancing contractor, the controls contractor, any other installing subcontractors or suppliers of commissioned equipment or systems and the facility or plant operator/engineer.

PART 2 - PRODUCTS NOT USED

PART 3 - EXECUTION

3.1 MEETINGS

- A. Kick-off Meeting: The Commissioning Provider will schedule, plan and conduct a commissioning kick-off meeting with the entire commissioning team in attendance, including the controls, electrical, plumbing, mechanical, adjusting and balancing and other appropriate Trade Subcontractors and the facility operator or Owner Representative in attendance. Prior to this meeting, the commissioning plan will be distributed to all members. The commissioning plan, the overall commissioning process and general responsibilities of each team member, reporting and communication protocols and next steps will be discussed. Meeting minutes will be distributed to all parties by the Commissioning Provider.
- B. Miscellaneous Meetings: Deficiencies identified through the commissioning process shall be discussed, as needed, in portions of regular construction meetings. Meetings dedicated to deficiencies or commissioning: status, coordination and planning shall also be conducted, if needed. The Commissioning Provider will plan, conduct and take minutes at commissioning meetings. When practical, commissioning meetings will be an appendage to regular construction meetings. All commissioning meetings shall be attended by the GC, the mechanical and the controls subcontractor. Selected meetings shall require the attendance of the electrical, TAB or other trades of commissioned systems.
- C. Controls Integration Meeting: The Commissioning Provider coordinates the meeting to go over the control drawings, sequences of operation included in the controls submittal. This meeting is held prior to the approval of the controls submittal. The intent is to clarify control related issues for the controls contractor, mechanical, fire alarm, plumbing and electrical contractor, facility staff and Commissioning Provider prior to startup, testing and balancing and functional testing.
 - 1. The controls contractor shall attend the meeting. The mechanical, electrical and general contractor shall attend when issues regarding equipment they are responsible for are discussed. The control technicians attending the meetings must be the same technicians that are/will install and program the DDC system.
 - 2. Primary issues discussed and clarified are:
 - a. Control drawing content
 - b. Point database (points (monitored points, software points, naming conventions, alarms, report format)
 - c. Sequences of operation and setpoints
 - d. Interlocks to packaged controls and other systems
 - e. Operator workstation graphics
 - f. Field sensor and panel locations
 - 3. The Commissioning Provider takes minutes at these meetings.

3.2 COMMISSIONING CHECKLISTS, START-UP, AND INITIAL CHECKOUT

A. The following procedures apply to all equipment and systems to be commissioned:

1. Commissioning Checklists:

- a. GC and Trade Subcontractors are to execute pre-functional system checks using the Commissioning Provider's created forms on the web based commissioning software Facility Grid.
- b. The Commissioning Provider develops and completes the commissioning checklists and procedures for commissioned equipment and systems.
- c. Calibrations: The construction checklists will contain requirements for calibrations when applicable. The Trade Subcontractors is responsible to calibrate all field-installed sensors and actuators using checkout documentation methods approved by the Commissioning Provider.

2. Manufacturer Installation and Startup Procedures:

- a. A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:
 - 1) Flushing and cleaning of pipe
 - 2) Filters, strainers, and screens.
 - 3) Valve/damper positions.
 - 4) Electrical tests.
 - 5) Safeties.
 - 6) Chemical treatment.
 - 7) Manufacturer's tests.
- b. The Trade Subcontractors shall complete the pre-start procedures in the manufacturer startup forms prior to starting equipment, including but not limited to verification of completion of wiring, safeties, lubrication, drive rotation and proper electrical test readings. Startup shall be conducted under supervision of responsible manufacturer representatives for major pieces of equipment. The GC shall notify the Commissioning Provider at least 5 days in advance of any equipment start-up, providing the Commissioning Provider a copy of the start-up plan at that time.
- c. The Commissioning Provider shall observe startup and checkout of selected systems.
- d. The Trade Subcontractors and manufacturer representatives shall execute start-up and provide the Commissioning Provider with a signed and dated copy of the completed start-up documentation. The Trade Subcontractors shall clearly note any items that have not been completed and the plan for their completion.
- e. The Trade Subcontractors shall operate each commissioned device or system to the full extent of its capability, from minimum to maximum, under automatic and manual control and verify that the equipment, system and assembly is functioning according to the specifications, manufacturer recommendations and good operating practice.
- f. The manufacturer startup reports and procedures for a given system shall be successfully completed and submitted prior to testing, adjusting and balancing of the equipment.

- g. The Commissioning Provider will review startup documentation and identify incomplete areas.
 - h. The Trade Subcontractors shall correct all areas that are deficient or incomplete in the startup documentation in a timely manner.
- 3. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.3 FUNCTIONAL TESTING

- A. Functional Performance Testing begins after operational testing, adjusting, and balancing of the systems have been completed by the Subcontractors. Functional tests for a given system shall not be conducted until they are fully operational under normal and reliable control with control calibrations, programming and control system graphics complete and checked out and the Trade Subcontractors have submitted completed, applicable startup reports, satisfactory to the Commissioning Provider.
- B. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.
- C. Any test ports, gauges, test equipment, etc., needed to accomplish the functional performance tests shall be provided by Subcontractors.
- D. Subcontractors shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall include dates, setpoints, calibration coefficients, control loop verification, and other data required to verify system check-out. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.4 DEFICIENCIES AND NON-CONFORMANCE

- A. Deficiency Management
 - 1. The Commissioning Provider will record the results of document reviews, field observations, tests conducted or reviewed and trend logs or monitoring. All deficiencies will be recorded on a Deficiency Log kept by the Commissioning Provider. The Deficiency Log will be kept updated by the Commissioning Provider.
 - 2. All deficiencies will be tracked using the online commissioning software Facility Grid. A current copy of the Deficiency Log will be provided to the GC and Owner/Owner Representative on a regular basis, as requested. New deficiencies will be identified.
 - 3. Items that are incomplete or are requiring Designer input will be sent to the Designer and Owner/Owner Representative by the Commissioning Provider via appropriate channels.
 - 4. When completion of a deficiency has been identified by the Commissioning Provider as holding up or is likely to delay any commissioning process, particularly functional testing, the GC, shall be required to notify the Commissioning Provider providing the planned actions and an expected date of completion. The GC shall notify the Commissioning Provider listing the actions taken to resolve the issue. It is not the

responsibility of the Commissioning Provider to obtain this status information through meeting attendance, asking questions or field observation.

5. The Commissioning Provider documents resolutions in the Deficiency Log and schedules retesting and backchecking as needed.
6. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the Commissioning Provider will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so.
 - a. The time for the Commissioning Provider to direct, document and evaluate any retesting required because a specific construction checklist or start-up test item, reported to have been successfully completed, but determined during testing to be faulty, will be charged to the GC.
 - b. The GC shall reimburse the Commissioning Provider for costs when a scheduled test cannot be completed due to:
 - 1) Failure of the GC to schedule the test with all parties required to perform the test or with regulatory authorities required to witness the test.
 - 2) Failure of the GC to provide required notice for tests that have been cancelled or rescheduled.
 - 3) Failure of the GC or Trade Subcontractors to have in place test equipment, support equipment, instrumentation, permits, or other ancillary equipment or systems required for successful execution of the test.
 - 4) Failure of the Trade Subcontractors to complete pre-start or start-up procedures or other work required as a prerequisite for execution of the test.
7. The GC shall respond in writing to the Commissioning Provider at least as often as commissioning meetings are being scheduled concerning the status of each outstanding deficiency identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.

- B. Approval and Acceptance: The Commissioning Provider will note each satisfactorily demonstrated function on the test form. Functional testing or acceptance of a system is indicated after all testing and monitoring is complete and there are no outstanding deficiencies for that equipment or system in the Commissioning Provider's Deficiency Log.

3.5 DEFERRED TESTING

- A. Unforeseen Deferred Tests: If any functional test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of functional testing may be delayed.
- B. Seasonal Testing: During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) specified in the testing requirements shall be completed as part of this contract. The Commissioning Provider will coordinate this activity. Tests will be executed, documented and deficiencies corrected by the Trade Subcontractors, with facilities staff and the Commissioning Provider witnessing. The Trade Subcontractors shall

make needed final adjustments to the O&M manuals and record documents due to the testing results.

3.6 ADDITIONAL DOCUMENTATION

A. Documentation required of the Trade Subcontractors shall consist of the following:

1. Startup and initial checkout forms completed.
2. Record of deficiencies and incomplete items for tests they are responsible to document.
3. Training record.

B. O&M Documentation Completion and Review:

1. Prior to substantial completion, the Commissioning Provider shall review the O&M manuals for systems that were commissioned to verify compliance with the specifications. The Commissioning Provider will communicate deficiencies in the manuals to the Commissioning Team.
2. The Commissioning Provider will also review each equipment warranty and verify that requirements to keep the warranty valid are clearly stated.
3. This work does not supersede the Design Team's review of the O&M manuals.

3.7 TRAINING OF FACILITY PERSONNEL

- A. The Trade Subcontractors are responsible to provide training for facility personnel per the Contract Documents. The Trade Subcontractors shall work with the Commissioning Provider to develop appropriate training and orientation agendas for equipment and systems and provide skilled trainers for the sessions. The Commissioning Provider will verify that the Trade Subcontractors execute training per the Contract Documents.

END OF SECTION 230800

SECTION 230923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 WORK INCLUDED GENERAL

- A. Furnish a totally native BACnet-based system, including a Windows 7 Professional, Windows Server 2008 R2 or SQL Server 2008 R2-compatible operator's workstation. The operator's workstation, all building controllers, application controllers, and all input/output devices shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2008, BACnet. In other words, all workstations and controllers, including unitary controllers, shall be native BACnet devices. No gateways shall be used for communication to controllers installed under this section. Gateways may be used for communication to existing systems or to systems installed under other sections.
- B. Provide all necessary BACnet-compliant hardware and software to meet the system's functional specifications. Provide Protocol Implementation Conformance Statement (PICS) for Windows-based control software and every controller in system, including unitary controllers.
- C. Prepare individual hardware layouts, interconnection drawings, and software configuration from project design data.
- D. Implement the detailed design for all analog and binary objects, system databases, graphic displays, logs, and management reports based on control descriptions, logic drawings, configuration data, and bid documents.
- E. Design, provide, and install all equipment cabinets, panels, data communication network cables needed, and all associated hardware.
- F. Provide and install all interconnecting cables between supplied cabinets, application controllers, and input/output devices.
- G. Provide and install all interconnecting cables between all operator's terminals and peripheral devices (such as printers, etc.) supplied under this section.
- H. Provide complete manufacturer's specifications for all items that are supplied. Include vendor name of every item supplied.
- I. Provide supervisory specialists and technicians at the job site to assist in all phases of system installation, startup, and commissioning.
- J. Provide a comprehensive operator and technician training program as described herein.
- K. Provide as-built documentation, operator's terminal software, diagrams, and all other associated project operational documentation (such as technical manuals) on approved media, the sum total of which accurately represents the final system.

- L. Provide new sensors, dampers, valves, and install only new electronic actuators. No used components shall be used as any part or piece of installed system.

1.2 SYSTEM DESCRIPTION

- A. Distributed logic control system complete with all software and hardware functions shall be provided and installed. System shall be completely based on ANSI/ASHRAE Standard 135-2008, BACnet and achieved listing under the BACnet Testing Laboratories BACnet - Advanced Workstation Software (B-AWS). This system is to control all mechanical equipment, including all unitary equipment such as VAV boxes, heat pumps, fan-coils, AC units, etc., and all air handlers, boilers, chillers, and any other listed equipment using native BACnet-compliant components. Non-BACnet-compliant or proprietary equipment or systems (including gateways) shall not be acceptable and are specifically prohibited.
- B. Operator's workstation software shall use Windows 7 Professional, Windows Server 2008 R2 or SQL Server 2008 R2 as the computer operating system.
- C. The Building Automation System (BAS) application program shall be written to communicate specifically utilizing BACnet protocols. Software functions delivered on this project shall include password protection, scheduling (including optimum start), alarming, logging of historical data, full graphics including animation, demand limiting, and a full suite of field engineering tools including graphical programming and applications. Systems using operating systems other than that described above are strictly prohibited. All software required to program application specific controllers and all field level devices and controllers will be left with the owner. All software passwords required to program and make future changes to the system will also become the property of the owner. All software required to make any program changes anywhere in the system, along with scheduling and trending applications, will be left with the owner. All software passwords required to program and make future changes to schedules, trends and related program changes will also become the property of the owner. All software required for all field engineering tools including graphical programming and applications will be left with the owner. All software passwords required to program and make future changes to field engineering tools, including graphical programming and applications will be left with the owner.
- D. Building controllers shall include complete energy management software, including scheduling building control strategies with optimum start and logging routines. All energy management software and firmware shall be resident in field hardware and shall not be dependent on the operator's terminal. Operator's terminal software is to be used for access to field-based energy management functions only. Provide zone-by-zone direct digital logic control of space temperature, scheduling, runtime accumulation, equipment alarm reporting, and override timers for after-hours usage.
- E. Room sensors shall be provided stainless steel plates with no adjustment or temperature readout.
- F. All application controllers for every terminal unit (VAV, HP, UV, etc.) air handler, all central plant equipment, and any other piece of controlled equipment shall be fully programmable. Application controllers shall be mounted next to controlled equipment and communicate with building controller through BACnet LAN.

1.3 APPROVED MANUFACTURERS

- A. BSD has standardized around Johnson Controls. No other manufacturers will be accepted. The base bid shall be by contractors authorized by Johnson Controls. (Johnson Controls, Inc., Northwest Control Contractors, or selected Johnson Controls Inc. Authorized Building Controls Specialist (ABCS), and their designated agents. Selection of Controls Contractors is subject to approval by BSD.)
- B. Approved Control Manufacturers:
 - 1. Johnson Controls.

1.4 QUALITY ASSURANCE

- A. The Building Automation System (BAS) system shall be designed, installed, commissioned, and serviced by manufacturer authorized and trained personnel. The Controls contractor shall be regularly engaged in the engineering, programming, installation, and service of Control systems by the selected manufacturer and shall have a minimum of five years' experience with the complete, turn-key installation of Controls by the same manufacturer of similar size and technical complexity. If portions of the installation will be performed by a subcontractor, the Controls Contractor will submit to the owner two sample installations performed by subcontractor which are similar to the current project. The controls contractors shall have local branch facility within a 75-mile radius of the job site. Emergency Service shall be available on a 24-hour, 7-day a week basis.
- B. The contractor shall provide an experienced project manager for this work, responsible for direct supervision of the design, installation, start-up and commissioning of the BAS system.
- C. Materials and equipment shall be manufacturer's latest standard design that complies with the specification requirements.
- D. All BAS peer-to-peer network controllers, central system controllers and local user displays shall be UL Listed under Standard UL 916, category PAZX.
- E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.
- F. Control system shall be engineered, programmed and supported completely by representative's local office.

1.5 REFERENCE STANDARDS

- A. The latest edition of the following standards and codes in effect and amended as of supplier's proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
 - 1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
 - 2. ANSI/ASHRAE Standard 135-2008, BACnet.

3. 2012 IBC - Effective July 1, 2014.
4. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
5. National Electrical Code (NEC).
6. FCC Part 15, Subpart J, Class A.
7. EMC Directive 89/336/EEC (European CE Mark).
8. BTL – BACnet Testing Laboratory

- B. City, county, state, and federal regulations and codes in effect as of contract date.
- C. Except as otherwise indicated, the system supplier shall secure and pay for all permits, inspections, and certifications required for his work, and arrange for necessary approvals by the governing authorities.

1.6 SUBMITTALS

A. Drawings

1. The system supplier shall submit engineered drawings, control sequence, and bill of materials for approval.
2. Drawings shall be submitted in the following standard sizes: 11" x 17" (ANSI B).
3. Submittal drawings and system documentation (see System Documentation) shall be provided to BSD, contractor and architects in pdf format that is searchable for all text in design drawings showing controls systems, equipment, devices, and materials.

B. System Documentation

Include the following in submittal package:

1. System configuration diagrams in simplified block format.
2. All input/output object listings and an alarm point summary listing.
3. Electrical drawings that show all system internal and external connection points, terminal block layouts, and terminal identification.
4. Complete bill of materials, valve schedule and damper schedule.
5. Manufacturer's instructions and drawings for installation, maintenance, and operation of all purchased items.
6. Overall system operation and maintenance instructions—including preventive maintenance and troubleshooting instructions.
7. For all system elements—operator's workstation(s), building controller(s), application controllers, routers, and repeaters—provide BACnet Protocol Implementation Conformance Statements (PICS) as per ANSI/ASHRAE Standard 135-2001.
8. Provide complete description and documentation of any proprietary (non-BACnet) services and/or objects used in the system.
9. A list of all functions available and a sample of function block programming that shall be part of delivered system.

C. Project Management

1. The vendor shall provide a detailed project design and installation schedule with time markings and details for hardware items and software development phases. Schedule

shall show all the target dates for transmission of project information and documents, and shall indicate timing and dates for system installation, debugging, and commissioning.

D. BACnet Device Object Naming Conventions

1. The BAS manufacturer's representative shall submit a BACnet Device Object Naming Convention Plan (DONCP) to the owner and consulting engineer during the submittal process. The plan must be approved by the owner and consulting engineer prior to implementation. It is the responsibility of the BAS contractor to coordinate the DONCP with the owner and consulting engineer.
2. The DONCP shall be designed to eliminate any confusion between individual points in a facility/campus wide EMCS system. It will also be designed to allow for future expansion and consistency. Each device on a BACnet internetwork (including other manufacturer's devices) must have a unique device instance. This is a major consideration when adding to an existing system or interconnecting networks. Thorough and accessible site documentation is critical.
3. A consistent object (point) naming convention shall be used to facilitate familiarity and operational ease across an eventual large campus or inventory of facilities. The following section is designed as recommendations only. It is the responsibility of the BAS contractor to coordinate the DONCP with the owner and consulting engineer to provide a naming convention that is compatible with BSD standards.
4. BACnet requires that all devices have a Device object name that is unique throughout the entire internetwork. To comply with this requirement all BACnet devices should be configured with a Device Object Name that is based on the naming conventions described in this section. This includes all physical devices as well as any logical BACnet devices that are represented by gateways. The vendor shall coordinate with the owner's staff to ensure that the correct names are used. Device Object Name properties shall support strings of at least 50 characters in length.
5. Follow naming convention as required
6. Every system device has addresses by which any other BACnet device can identify it and route information to and from it. Although there are a number of addresses to consider, the scheme is fairly straightforward. It can become complicated, however, if addresses have not been documented adequately or there is no logical addressing scheme.
7. When you set up and plan a BACnet network or add to an existing network, considering and documenting your addressing scheme is of the utmost importance. Adopt a hierarchical and uniform addressing scheme for device instances to help you quickly identify the function and location of different devices when troubleshooting. Additionally, it's very important to document every element of your addressing scheme and update the site documentation with any changes.
8. This section first covers the important addressing issues with respect to BACnet LANs and it gives a practical application you can use to check your understanding.
9. BACnet addressing
10. Three types of addresses are important in any BACnet system: network numbers, media access control (MAC) addresses, and device instances. Each BACnet device has these addresses associated with it. Though all three can be thought of as addresses, they are all very different both in how they function and how they are assigned.
11. Network numbers Identifies the network to which a BACnet device belongs. Every network on a BACnet LAN has a unique numerical identifier—a network number. This network number is used by BACnet devices only; it does not rely on nor does it affect any other network protocols. LANs connected by a router must have different network

numbers. No interconnected BACnet networks can have the same network number. Network number range is 1–65,534, for a maximum of 65,534 interconnected BACnet networks.

IMPORTANT BACnet reserves network numbers 0 and 65,535 for special purposes. Don't use network 0 or 65,535.

12. MAC addresses Hardware-oriented. The MAC address uniquely identifies a device on its particular network. Each network type—Ethernet and MS/TP—has its own MAC addressing scheme. A device that exists on two or more networks will have a MAC address for each one. Devices can have the same MAC addresses as long as they are on networks with different network numbers.
13. Note It's helpful to think of the MAC address as a house number and the network number as the street number. Two houses can have the same house number (MAC address) as long as they are on different streets (networks).
 - a. Ethernet devices: For Ethernet LANs, the IEEE assigns a certain range of MAC addresses to manufacturers of Ethernet products. The manufacturer then assigns a unique MAC address to each of its Ethernet devices.
 - b. MS/TP devices: For devices on an MS/TP LAN, you assign the MAC address for each controller. For BACtalk VLCs, these are assigned with DIP switches. Devices on an MS/TP LAN are designated as either masters or slaves, which affects how they can be addressed. This is a requirement of the BACnet specification. All BACtalk MS/TP devices are masters.
 - c. **IMPORTANT** BACnet reserves MS/TP MAC address 255 for special purposes. Don't use MS/TP MAC 255.
 - d. Device instances Software-oriented. The device instance identifies the device to the BACnet software and is the address most often encountered. The device instance is a shortcut to having to specify a MAC address and network number each time an operation is performed. Device instances range from 0–4194302.
 - e. Note BACnet reserves device instance 4194303 for special purposes. Don't use device instance 4194303.

1.7 WARRANTY

- A. Warranty shall cover all costs for parts, labor, associated travel, and expenses for a period of one (1) year from completion of system acceptance.
- B. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the vendor. The maximum acceptable response time to provide this service at the site shall be 24 hours, Monday through Friday, and 48 hours on Saturday and Sunday.
- C. This warranty shall apply equally to both hardware and software.

1.8 RELATED WORK IN OTHER SECTIONS

- A. Refer to Division 0 and Division 1 for related contractual requirements.
- B. Refer to other sections in Division 23 for General Mechanical Provisions.

- C. Refer to Division 26 for General Electrical Provisions.

PART 2 - PRODUCTS

2.1 WEB INTERFACE

A. General

- B. BAS supplier shall provide web-based access to the system as part of standard installation. User must be able to access all displays of real-time data that are part of the BAS using a standard web browser. Web browser shall tie into the network through owner-supplied Ethernet network connection. Browser Technology

1. Browser shall be Internet Explorer v9.0 or later, Firefox v3.6 or later, Safari v2.0 or later (on Mac OS X). WEBtalk browsers: Internet Explorer 8.0, Firefox, Safari on Mac. . No special vendor-supplied software shall be needed on computers running browser. All displays shall be viewable and the webpage host shall directly access real-time data from the BAS BACnet network. Data shall be displayed in real-time and update automatically without user interaction. User shall be able to change data on displays if logged in with the appropriate user name and password.

C. Communications

1. BAS BACnet Ethernet network shall be provided and installed by the BAS supplier. Owner shall provide and incur any monthly charges of WAN/Internet connection.

D. Display of Data

1. Webpage graphics shown on browser shall be replicas of the BAS displays. User shall need no additional training to understand information presented on webpages when compared to what is shown on BAS displays. Webpage displays shall include animation just as BAS displays. Fans shall turn, pilot lights shall blink, coils shall change colors, and so on.
2. Real-time data shall be shown on all browser webpages. This data must be directly gathered using the BACnet network and automatically updated on browser webpage displays without any user action. Data on the browser shall automatically refresh as changes are detected without re-drawing the complete display.
3. It shall be possible for user from browser webpage to change data if the user is logged on with the appropriate password. Clicking on a button or typing in a new value shall change digital data. Using pull-down menus or typing in a new value shall change analog data.
4. Data displays shall be navigated using pushbuttons on the displays that are simply clicked on with the mouse to select a new display. Alternatively, the standard back and forward buttons of the browser can be used for display navigation.

E. Time Schedule Adjustment

1. Web access shall allow user to view and edit all schedules in the system. This includes standard, holiday and event schedules as described in BAS specification. Display of

schedules shall show interaction of all schedules on a single display so user sees an overview of how all work together. User shall be able to edit schedules from this display.

2. Display of all three schedules must show all ON times for standard, holiday and event schedules in different colors on a given day. In addition, OFF times for each must also be shown in additional colors. User shall be able to select from standard calendar what days are to be scheduled and same display shall show all points and zones affected. User shall be able to set time for one day and select all days of the week that shall be affected as a recurrence of that same schedule for that given day.
3. Schedule list shall show all schedules currently defined. This list shall include all standard, holiday and event schedules. In addition, user shall be able to select a list that shows all scheduled points and zones.

F. Logging of Information

1. User shall use standard browser technology to view all trendlogs in system. User shall be able to view logged data in tabular form or graphical format. User shall be able to adjust time interval of logged data viewed and shall be able to adjust Y axis of data viewed in graphical format. User shall also be able to download data through the web interface to local computer. Data shall be in CSV format.

G. Alarm Handling

1. Web interface shall display alarms as they occur. User shall be able to acknowledge alarms using browser technology. In addition, user shall be able to view history of alarm occurrence over a user-selected time frame. In addition, those alarms may be filtered for viewing per user-selected options. A single selection shall display all alarms that have not been acknowledged.

H. Webpage Generation

1. Webpages shall be automatically generated from the BAS displays that reside on the BAS server. User shall access webpage host through the network and shall initiate a webpage generation utility that automatically takes the BAS displays and turns them into webpages. The webpages generated are automatically installed on the webpage host for access using any computer's standard browser. Any system that requires use of an HTML editor for generation of webpages shall not be considered.

I. Password Security and Activity Log

1. Access through web browser shall utilize the same hierarchical security scheme as BAS system. User shall be asked to log on once the browser makes connection to webpage host. Once the user logs in, any and all changes that are made shall be tracked by the BAS system. The user shall be able to change only those items he or she has authority to change. A user activity report shall show any and all activity of the users who have logged in to the system, regardless of whether those changes were made using a browser or through the BAS workstation.

J. BACnet Communication

1. Web server shall directly communicate to all devices on the BAS network using BACnet protocol. No intermediate devices shall be necessary for BACnet communication.

2.2 BUILDING CONTROLLER

A. General Requirements

1. BACnet Conformance
 - a. Building Controller shall be approved by the BTL as meeting the BACnet Building Controller requirements.
 - b. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
2. Building controller shall be of scalable design such that the number of trunks and protocols may be selected to fit the specific requirements of a given project.
3. The controller shall be capable of panel-mounted on DIN rail and/or mounting screws.
4. The controller shall be capable of providing global control strategies for the system based on information from any objects in the system, regardless if the object is directly monitored by the building controller module or by another controller.
5. The controller shall be capable of running up to six independent control strategies simultaneously. The modification of one control strategy does not interrupt the function or runtime others.
6. The software program implementing the DDC strategies shall be completely flexible and user-definable. All software tools necessary for programming shall be provided as part of project software. Any systems utilizing factory pre-programmed global strategies that cannot be modified by field personnel on-site, using a WAN or downloaded through remote communications are not acceptable. Changing global strategies using firmware changes is also unacceptable.
7. Programming shall be object-oriented using control function blocks, and support DDC functions. All flowcharts shall be generated and automatically downloaded to controller. Programming tool shall be supplied and be resident on workstation. The same tool shall be used for all controllers.
8. Programming tool shall provide means to graphically view inputs and outputs to each program block in real-time as program is executing. This function may be performed using the operator's workstation or field computer.
9. Controller shall have 6000 Analog Values and 6000 Binary Values
10. Controller IP configuration can be done via a direct USB connect with a operator's workstation or field computer.
11. Controller shall have at a minimum a Quad Core 996Ghz processor to ensure fast processing speeds.
12. Global control algorithms and automated control functions shall execute using a 64-bit processor.
13. Controller shall have a minimum of 1 GB of DDR3 SDRAM on a 533Mhz bus to ensure high speed data recording, large data storage capacity and reliability.

14. Controller shall support two on-board EIA-485 ports capable of supporting various EIA-485 protocols including but not limited to BACnet MS/TP and Modbus.
 - a. Ports are capable of supporting various EIA-485 protocols including but not limited to BACnet MS/TP and Modbus.
15. Controller shall support two gigabit speed Ethernet (10/100/1000) ports.
 - a. Ports are capable of supporting various Ethernet protocols including but not limited to BACnet IP, FOX, and Modbus.
16. All ports shall be capable of having protocol(s) assigned to utilize the port's physical connection
17. The controller shall have at a minimum four onboard inputs, two universal inputs and two binary inputs.
18. Schedules
 - a. Building controller modules shall provide normal seven-day scheduling, holiday scheduling and event scheduling.
 - b. Each building controller shall support a minimum of 380 BACnet Schedule Objects and 380 BACnet Calendar Objects.
19. Logging Capabilities
 - a. Each building controller shall log as minimum 2000 objects at 15 min intervals. Any object in the system (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
 - b. Logs may be viewed both on-site and off-site using WAN or remote communication.
 - c. Building controller shall periodically upload trended data to networked operator's workstation for long-term archiving if desired.
 - d. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.
20. Alarm Generation
 - a. Alarms may be generated within the system for any object change of value or state (either real or calculated). This includes things such as analog object value changes, binary object state changes, and various controller communication failures.
 - b. Each alarm may be dialed out as noted elsewhere.
 - c. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
 - d. Controller must be able to handle up to 2000 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.
21. Demand Limiting

- a. Demand limiting of energy shall be a built-in, user-configurable function. Each controller module shall support shedding of up to 1200 loads using a minimum of two types of shed programs.
- b. Load shedding programs in building controller modules shall operate as defined in section 2.1.J of this specification.

22. Tenant Activity Logging

- a. Tenant Activity logging shall be supported by building controller module. Each independent module shall support a minimum of 380 zones.
- b. Tenant Activity logging shall function as defined in section 2.1.K of this specification.

B. BACnet MS/TP

1. BACnet MS/TP LAN must be software-configurable from 9.6 to 115.4Kbps
 - a. Each BACnet MS/TP LAN shall support 64 BACnet devices at a minimum
 - b. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. BACnet IP

1. The building controller shall comply with Annex J of the BACnet specification for IP connections. This device shall use Ethernet to connect to the IP internetwork, while using the same Ethernet LAN for non-IP communications to other BACnet devices on the LAN.
2. Must support interoperability on WANs and CANs and function as a BACnet Broadcast Management Device (BBMD).
3. Each controller shall support at a minimum 128 BBMD entries
4. BBMD management architecture shall support 3000 subnets at a minimum
5. Shall support BACnet Network Address Translation
6. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

D. Expansion ports

1. Controller shall support two expansion ports.
 - a. Combining the two on-board EIA-458 ports with fully loaded expansion ports the controller shall support 6 EIA-485 trunks simultaneously
2. Expansion cards that mate to the expansion ports shall include:
 - a. Dual port EIA-485 card

E. Power Supply

1. Input for power shall accept between 17–30VAC, 47–63Hz.
2. Optional rechargeable battery for shutdown of controller including storage of all data in flash memory
3. On-board capacitor will ensure continuous operation of real-time clocks for minimum of 14 days.

F. Controller shall be in compliance with the following

1. UL 916 for open energy management
2. FCC Class B
3. ROHS
4. IEC 60703
5. C-Tick Listed

G. Controller shall operate in the following environmental conditions:

1. -4 to 149 °F (-20 to 65 °C) without optional battery, or 32 to 122 °F (0 to 50 °C) with optional battery
2. 0 to 95% RH, non-condensing

2.3 CENTRAL PLANT AND AIR HANDLER APPLICATION CONTROLLERS

A. Provide one or more native BACnet application controllers for each air handler and provide native BACnet application controllers as needed for central plant control that adequately cover all objects listed in object list. All controllers shall interface to building controller through either MS/TP LAN using BACnet protocol, or Ethernet LAN using BACnet over Ethernet or BACnet TCP/IP. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of units. Controllers shall be fully programmable using graphical programming blocks. Programming tool shall be resident on operator workstation and be the same tool as used for the building controller. No auxiliary or non-BACnet controllers shall be used.

B. BACnet Conformance

1. Application controllers shall be approved by the BTL as meeting the BACnet Advanced Application Controller requirements.
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Multi-state Values, Device, File, and Program object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 12-bit resolution that accept 3K and 10K thermistors, 0–10VDC, Platinum 1000 Ohm RTD, 0–5VDC, 4–20mA and dry contact

signals. Any input on a controller may be either analog or digital with a minimum of three (3) inputs that accept pulses. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary and analog outputs on board. Analog outputs with 12-bit resolution shall support either 0–10VDC or 0–20mA. Binary outputs shall have LED indication of status. Software shall include scaling features for analog outputs. Application controller shall include 20VDC voltage supply for use as power supply to external sensors.

1. All outputs must have on-board Hand-Off-Auto (HOA) switches and a status indicator light. HOA switch position shall be monitored. Each analog output shall include a potentiometer for manually adjusting the output when the HOA switch is in the Hand position. The position of each and every HOA switch shall be available system wide as a BACnet object property.
- D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller up to 20 times per second (minimum of 10 times per second) and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal.
1. The following control blocks shall be supported:
 - a. Natural Log
 - b. Exponential
 - c. Log base 10
 - d. X to the power of Y
 - e. Nth square root of X
 - f. 5th Order Polynomial Equations
 - g. Astronomical Clock (sunrise/sunset calculation)
 - h. Time-based schedules
- E. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using programming tools as described in operator's terminal section.
- F. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on intelligent room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode, based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.
- G. Schedules
1. The controller shall support a minimum of three (3) BACnet Schedule Objects and have a real-time clock on board with battery backup to maintain time through a power loss.

H. Logging Capabilities

1. Controller shall support a minimum of 50 trendlogs. Any object in the controller (real or calculated) may be logged. Sample time interval shall be adjustable at the operator's workstation.
2. Controller shall periodically upload trended data to system server for long-term archiving if desired. Archived data stored in (MS Jet Database or SQL) database form and shall be available for use in third-party spreadsheet or database programs.

I. Alarm Generation

1. Alarms may be generated within the controller for any object change of value or state (either real or calculated). This includes things such as analog object value changes, and binary object state changes.
2. Alarm log shall be provided for alarm viewing. Log may be viewed on-site at the operator's terminal or off-site using remote communications.
3. Controller must be able to handle up to 25 alarm setups stored as BACnet event enrollment objects, with system destination and actions individually configurable.

J. The controller processor shall be a 32-bit processor.

K. The packaging of the controller shall provide operable doors to cover the terminals once installation is complete. The housing of the controller shall provide for DIN rail mounting and also fully enclose circuit board.

2.4 TERMINAL UNIT APPLICATION CONTROLLERS (Heat Pumps, AC Units, Fan-Coils, Boilers, Mini Split Systems)

A. Provide one (1) native BACnet application controller for each piece of unitary mechanical equipment that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include input, output and self-contained logic program as needed for complete control of unit.

B. BACnet Conformance

1. Application controllers shall, as a minimum, support MS/TP BACnet LAN types. They shall communicate directly using this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements and support all BACnet services necessary to provide the following BACnet functional groups:
 - a. Files Functional Group
 - b. Reinitialize Functional Group
 - c. Device Communications Functional Group
2. Please refer to Section 22.2, BACnet Functional Groups in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be

- thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5VDC, 4–20mA, dry contact signals and a minimum of three (3) pulse inputs. Any input on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor. Controller shall include binary outputs on board with analog outputs as needed.
- D. All program sequences shall be stored on board controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely through modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using same programming tools as building controller and as described in operator workstation section. All programming tools shall be provided and installed as part of system.
- E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operation for specific display requirements at intelligent room sensor.

2.5 VAV BOX CONTROLLERS—SINGLE DUCT

- A. Provide one (1) native BACnet application controller for each VAV box that adequately covers all objects listed in object list for unit. All controllers shall interface to building controller through MS/TP LAN using BACnet protocol. No gateways shall be used. Controllers shall include on board CFM flow sensor, inputs, outputs and programmable, self-contained logic program as needed for control of units.
- B. BACnet Conformance
1. Application controllers shall, at a minimum, support MS/TP BACnet LAN types. They shall communicate directly through this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements.
 2. Please refer to Section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

3. Standard BACnet object types supported shall include, as a minimum, Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, and Program Object Types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
- C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC, and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall also include binary outputs on board. For applications using variable speed parallel fans, provide a single analog output selectable for 0–10 V or 0–20 mA control signals. Application controller shall include microprocessor driven flow sensor for use in pressure independent control logic. All boxes shall be controlled using pressure-independent control algorithms and all flow readings shall be in CFM (LPS if metric).
- D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and shall be capable of multiple PID loops for control of multiple devices. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely using modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller and as described in operator's workstation section. All programming tools shall be provided as part of system.
- E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on room sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor. See sequence of operations for specific display requirements for intelligent room sensor.
- F. On-board flow sensor shall be microprocessor-driven and pre-calibrated at the factory. Pre-calibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in non-volatile memory. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent room sensor. Operator's workstation, portable computers, and special hand-held field tools shall not be needed for field calibration.
- G. Provide duct temperature sensor at discharge of each VAV box that is connected to controller for reporting back to operator's workstation.

2.6 VAV BOX CONTROLLERS

- A. Provide one and only one native BACnet application controller for each VAV box that adequately covers all objects listed in object list for unit. Systems that use two or more controllers for control of a single VAV box shall be rejected. All controllers shall interface to building controller via MS/TP LAN using BACnet protocol. No gateways shall be used.

Controllers shall include two (2) on-board flow sensors, inputs, outputs and self-contained logic program as needed for control of units.

B. BACnet Conformance

1. Application controllers shall as a minimum support MS/TP BACnet LAN types. They shall communicate directly via this BACnet LAN at 9.6, 19.2, 38.4 and 76.8 Kbps, as a native BACnet device. Application controllers shall be approved by the BTL as meeting the BACnet Application Specific Controller requirements.
2. Please refer to section 22.2, BACnet Functional Groups, in the BACnet standard, for a complete list of the services that must be directly supported to provide each of the functional groups listed above. All proprietary services, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.
3. Standard BACnet object types supported shall include as a minimum—Analog Input, Analog Output, Analog Value, Binary Input, Binary Output, Binary Value, Device, File, Program and Schedule object types. All proprietary object types, if used in the system, shall be thoroughly documented and provided as part of the submittal data. All necessary tools shall be supplied for working with proprietary information.

C. Application controllers shall include universal inputs with 10-bit resolution that can accept 3K and 10K thermistors, 0–5 VDC and dry contact signals. Inputs on controller may be either analog or digital. Controller shall also include support and modifiable programming for interface to intelligent room sensor with digital display. Controller shall include binary outputs on board. Application controller shall include two (2) microprocessor driven flow sensors, one for hot deck and one for cold deck, for use in pressure-independent control logic. All boxes shall be controlled using pressure independent control algorithms and all flow readings shall be in CFM (LPS if metric).

D. All program sequences shall be stored on board application controller in EEPROM. No batteries shall be needed to retain logic program. All program sequences shall be executed by controller 10 times per second and capable of multiple PID loops for control of multiple devices. All calculations shall be completed using floating-point math and system shall support display of all information in floating-point nomenclature at operator's terminal. Programming of application controller shall be completely modifiable in the field over installed BACnet LANs or remotely via modem interface. Operator shall program logic sequences by graphically moving function blocks on screen and tying blocks together on screen. Application controller shall be programmed using the same programming tool as Building Controller as described in operator workstation section. All programming tools shall be provided as part of system.

E. Application controller shall include support for intelligent room sensor (see Section 2.9.B.) Display on field sensor shall be programmable at application controller and include an operating mode and a field service mode. All button functions and display data shall be programmable to show specific controller data in each mode based on which button is pressed on the sensor.

F. On-board flow sensor shall be microprocessor driven and precalibrated at the factory. Precalibration shall be at 16 flow points as a minimum. All factory calibration data shall be stored in EEPROM. Calibration data shall be field adjustable to compensate for variations in VAV box type and installation. All calibration parameters shall be adjustable through intelligent

room sensor. Operator workstation, portable computers and special hand-held field tools shall not be needed for field calibration.

- G. Provide duct temperature sensors at discharge of cold duct and hot duct for report of data at operator workstation.

2.7 AUXILIARY CONTROL DEVICES

A. Temperature Sensors

- 1. All temperature sensors to be solid-state electronic, interchangeable with housing appropriate for application. Wall sensors to be installed as indicated on drawings. Mount 48 inches above finished floor. Duct sensors to be installed such that the sensing element is in the main air stream. Immersion sensors to be installed in wells provided by control contractor, but installed by mechanical contractor. Immersion wells shall be filled with thermal compound before installation of immersion sensors. Outside air sensors shall be installed away from exhaust or relief vents, not in an outside air intake, and in a location that is in the shade most of the day.

B. Wall Sensor (for spaces with temperature control only)

- C. Blank brushed stainless steel wall plate with high precision 10K ohm Type II thermistor epoxied to the backside. Pack the back of the sensor with insulation where there is potential for in-wall draft. Avoid mounting temperature sensor on outside walls or next to doors leading to the hallway. After-hours override pushbutton on sensors for cafeteria, gym, library and front office only. Room Carbon Dioxide CO₂ with Temperature Sensor (for spaces with CO₂ & temperature control). Pack the back of the sensor with insulation where there is potential for in-wall draft. Avoid mounting temperature sensor on outside walls or next to doors leading to the hallway. After-hours override pushbutton on sensors for cafeteria, gym, library and front office only.

- 1. Input Power 12 to 30VDC/24AC; 100mA Maximum
- 2. Analog Output 0-10VDC
- 3. Operating Temperature Range 0° to 50°C (32° to 122°F)
- 4. Housing Material High impact plastic
- 5. Sensor Type Non-dispersive infrared, diffusion sampling
- 6. Measurement Range 0-2000/5000 ppm
- 7. Accuracy ± 40 ppm $\pm 3\%$ of measured value*
- 8. Repeatability ± 20 ppm $\pm 1\%$ of measured value
- 9. Response Time <60 seconds for 90% step change
- 10. Sample time 3 seconds.
- 11. Memory Digital CMOS

2.8 ELECTRONIC ACTUATORS AND VALVES

A. Quality Assurance for Actuators and Valves

- 1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.

2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
3. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.
4. All valves and actuators shall be manufactured by Belimo USA.

B. Execution Details for Actuators and Valves

1. Furnish a Freeze-stat and install "Hard Wire" interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
2. VAV damper actuators and valves are tri-state, utilizing a true PI algorithm from the controller. 4-20 ma or 1-10VDC are not acceptable.
3. Primary valve control shall be analog (2–10 VDC, 4–20 mA).

C. Actuators for damper and control valves 0.5–6 inches shall be electric unless otherwise specified, provide actuators as follows:

1. UL Listed Standard 873 and Canadian Standards Association Class 481302 shall certify actuators.
2. NEMA 2 rated actuator enclosures for inside mounting. Use additional weather shield to protect actuator when mounted outside.
3. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.
4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
5. Position indicator device shall be installed and made visible to the exposed side of the actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the actuator.
6. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
7. A pushbutton gearbox release shall be provided for all non-spring actuators.
8. Modulating actuators shall be 24 VAC and consume 10 VA power or less.
9. Conduit connectors are required when specified and when code requires it.

D. Damper Actuators

1. Outside air and exhaust air damper actuators shall be mechanical spring return. Capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
2. AHU economizer actuators shall utilize analog control 4-20 ma or 2–10 VDC; floating control is not acceptable.
3. Electric damper actuators (including VAV box actuators) shall be direct shaft-mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or set-screw type fasteners are not acceptable.

4. One (1) electronic actuator shall be direct shaft-mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one (1) actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One (1) electronic actuator shall be direct shaft-mounted per damper section. (See below execution section for more installation details.)

E. Valve Actuators 0.5–6 inches

1. Modulating valves and actuators on air handlers shall be 4-20 ma or 0-10VDC. Mechanical spring shall be provided on all actuators for pre-heat coil and actuators for AHU heating or cooling coil when units are mounted outside. See plans for fail-safe flow function: Normal Open or Normal Closed. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
2. All zone service actuators shall be non-spring return unless otherwise specified.
3. The valve actuator shall be capable of providing the minimum torque required for proper valve close-off for the required application.
4. All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
5. Override handle and gearbox release shall be provided for all non-spring return valve actuators.

F. Control Dampers.

1. The sheet metal contractor shall furnish and size all automatic control dampers unless provided with packaged equipment. The sheet metal contractor shall install all dampers unless provided with packaged equipment.
2. All dampers used for modulating service shall be opposed blade type and arranged for normally open or normally closed operation as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
3. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.
4. Damper linkage hardware shall be constructed of aluminum or corrosion-resistant zinc and nickel-plated steel and furnished as follows:
 - a. Bearing support bracket and drive blade pin extension shall be provided for each damper section. Sheet metal contractor shall install bearing support bracket and drive blade pin extension. Sheet metal contractor shall provide permanent indication of blade position by scratching or marking the visible end of the drive blade pin extension.
 - b. Drive pin may be round only if V-bolt and toothed V-clamp is used to cause a cold weld effect for positive gripping. For single bolt or set-screw type actuator fasteners, round damper pin shafts must be milled with at least one side flat to avoid slippage.
5. Damper manufacturer shall supply alignment plates for all multi-section dampers.

G. Control Valves 0.5–6 inches

1. The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor shall furnish all control wiring to actuators. The plumbing contractor shall install all valves. Equal percentage control characteristic shall be provided for all water coil control valves. Linear valve characteristic is acceptable for 3-way valves that are 2.5 inches and above.
2. Characterized control valves shall be used for hydronic heating or cooling applications and small to medium AHU water-coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted. If the coil is exposed to the outside air stream, see plans for spring return requirement.
 - a. Leakage is 0% (zero percent), close-off is 200psi, maximum differential is 30psi; rangeability is 500:1.
 - b. Valves 0.5–2 inches shall be nickel-plated forged brass body, NPT screw type connections.
 - c. Valves 0.5–1.25 inches shall be rated for ANSI Class 600 working pressure. Valves 1.5 and 2 inches shall be rated for ANSI Class 400 working pressure.
 - d. The operating temperature range shall be 0–250 degrees F.
 - e. Stainless steel ball and stem shall be furnished on all modulating valves.
 - f. Seats shall be fiberglass reinforced Teflon.
 - g. Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.
 - h. Three-way valve shall be applicable for both mixing and diverting.
 - i. The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.
 - j. The valves shall have a blow-out proof stem design.
 - k. The stem packing shall consist of two (2) lubricated O-rings designed for on-off or modulating service and require no maintenance.
 - l. The valves shall have an ISO type, 4-bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe.
 - m. A non-metallic thermal isolation adapter shall separate valve flange from actuator.
 - n. One (1) fastening screw shall secure the direct coupling of the thermal isolation adapter between the actuator and the valve. This will prevent all lateral or rotational forces from affecting the stem and its packing O-rings.
3. Globe valves 0.5–2 inches shall be used for steam control or water flow applications.
 - a. Valves shall be bronze body, NPT screw type, and shall be rated for ANSI Class 250 working pressure.
 - b. Valves 0.5 inches (DN15) through 2 inches (DN50) with spring return actuators shall close off against 50 psi pressure differential with Class III leakage (0.1%).
 - c. The operating temperature range shall be 20–280 degrees F.
 - d. Spring loaded TFE packing shall protect against leakage at the stem.
 - e. Two-way valves shall have an equal percentage control port.
 - f. Three-way valves shall have a linear control and bypass port.
 - g. Mixing and diverting valves must be installed specific to the valve design.
4. Globe Valves 2.5–6 inches

- a. Valves 2.5 inches (DN65) through 6 inches (DN50) shall be iron body, 125 lb. flanged with Class III (0.1%) close-off leakage at 50 psi differential.
- b. Valves with spring return actuators shall close off against 50 psi pressure differential with Class III leakage (0.1%).
- c. Flow type for two-way valves shall be equal percentage. Flow type for three-way valves shall be linear.
- d. Mixing and diverting valves must be installed specific to the valve design.

H. Butterfly valves

1. Butterfly valves shall be sized for modulating service at 60–70 degree stem rotation. Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats.
 - a. Body is cast iron.
 - b. Disc is aluminum bronze standard.
 - c. Seat is EPDM standard.
 - d. Body Pressure is 200 psi, -30–275 degrees F.
 - e. Flange is ANSI 125/250.
 - f. Media Temperature Range is -22–240 degree F.
 - g. Maximum Differential Pressure is 200 psi for 2- to 6- inch size.

I. Butterfly Valve Industrial Actuators

1. Actuators shall be approved under Canadian Standards Association or other Nationally Recognized Testing Laboratory to UL standards. CSA Class 4813 02 or equal. Enclosure shall be NEMA 4 (weatherproof) enclosure and will have an industrial quality coating.
 - a. Actuator shall have a motor rated for continuous duty. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on a 120 VAC, 1pH, 60 Hz supply. Two (2) adjustable cam-actuated end travel limit switches shall be provided to control direction of travel. A self-resetting thermal switch shall be imbedded in the motor for overload protection.
 - b. Reduction gearing shall be designed to withstand the actual motor stall torque. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
 - c. Actuator shall have a 6-foot wiring harness provided for ease in field wiring (above 1500 in-lbs). Two (2) adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC shall be provided for indication of open and closed position. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
 - d. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator and when in manual operation electrical power to the actuator will be permanently interrupted. The hand wheel will not rotate while the actuator is electrically driven.
 - e. The actuator shall be analog, floating, or two position as called out in the control sequence of operation. All Analog valves shall be positive positioning, and respond to a 2–10 VDC, 4-20 mA, or adjustable signal as required. Analog

actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.

2. Performance Verification Test

- a. Control loops shall cause productive actuation with each movement of the actuator and actuators shall modulate at a rate that is stable and responsive. Actuator movement shall not occur before the effects of previous movement have affected the sensor.
- b. Actuator shall have capability of signaling a trouble alarm when the actuator Stop-Go Ratio exceeds 30%.

3. Actuator mounting for damper and valve arrangements shall comply with the following:

- a. Damper actuators: Shall not be installed in the air stream.
- b. A weather shield shall be used if actuators are located outside. For damper actuators, use clear plastic enclosure.
- c. Damper or valve actuator ambient temperature shall not exceed 122 degrees F through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.
- d. Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.

4. Valve Sizing for Water Coil

- a. On/Off control valves shall be line-size.
- b. Modulating control valve body size may be reduced, at most, two (2) pipe sizes from the line size or not less than half the pipe size. The BAS contractor shall size all water coil control valves for the application as follows:
 - 1) Modulating control valves shall be sized for maximum of 5 psig pressure drop at full open position.
 - 2) Butterfly valves shall be sized for modulating service at 60–70 degree rotation. Design velocity shall be 12 feet per second or less when used with standard EPDM seats.
- c. Valve mounting arrangements shall comply with the following:
 - 1) Unions shall be provided on all ports of two-way and three-way valves.
 - 2) Install three-way equal percentage characterized control valves in a mixing configuration with the “A” port piped to the coil.
 - 3) Install 2.5 inches and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

2.9 ENCLOSURES

- A. All controllers, power supplies and relays shall be mounted in enclosures.
- B. Enclosures may be NEMA 1 when located in a clean, dry, indoor environment. Indoor enclosures shall be NEMA 12 when installed in other than a clean environment.
- C. Enclosures shall have hinged, locking doors.
- D. Provide laminated plastic nameplates for all enclosures in any mechanical room or electrical room. Include location and unit served on nameplate. Laminated plastic shall be 0.125 inches thick and appropriately sized to make label easy to read.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to starting work, carefully inspect installed work of other trades and verify that such work is complete to the point where work of this section may properly commence.
- B. Notify the owner's representative in writing of conditions detrimental to the proper and timely completion of the work.
- C. Do not begin work until all unsatisfactory conditions are resolved.

3.2 INSTALLATION (GENERAL)

- A. Install in accordance with manufacturer's instructions.
- B. Provide all miscellaneous devices, hardware, software, interconnections, installation, and programming required to ensure a complete operating system in accordance with the sequences of operation and point schedules.

3.3 LOCATION AND INSTALLATION OF COMPONENTS

- A. Locate and install components for easy accessibility; in general, mount 48 inches above floor with minimum three (3) feet of clear access space in front of units. Obtain approval on locations from owner's representative prior to installation.
- B. All instruments, switches, transmitters, etc., shall be suitably wired and mounted to protect them from vibration, moisture, and high or low temperatures.
- C. Identify all equipment and panels. Provide permanently mounted tags for all panels.
- D. Provide stainless steel or brass thermowells suitable for respective application and for installation under other sections, and sized to suit pipe diameter without restricting flow.

3.4 INTERLOCKING AND CONTROL WIRING

- A. Provide all interlock and control wiring. All wiring shall be installed neatly and professionally, in accordance with Specification Division 16 and all national, state and local electrical codes.
- B. Provide wiring as required by functions as specified and as recommended by equipment manufacturers, to serve specified control functions. Provide shielded low capacitance wire for all communications trunks.
- C. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the owner's representative prior to rough-in.
- D. Provide auxiliary pilot duty relays on motor starters as required for control function.
- E. Provide power for all control components from nearest electrical control panel or as indicated on the electrical drawings; coordinate with electrical contractor.
- F. All control wiring in the mechanical, electrical, telephone and boiler rooms to be installed in raceways. All other wiring to be installed neatly and inconspicuously per local code requirements. If local code allows, control wiring above accessible ceiling spaces may be run with plenum-rated cable (without conduit).

3.5 DDC OBJECT TYPE SUMMARY

- A. Provide all database generation.
- B. Displays
 - 1. System displays shall show all analog and binary object types within the system. They shall be logically laid out for easy use by the owner. Provide outside air temperature indication on all system displays associated with economizer cycles.
- C. Run Time Totalization
 - 1. At a minimum, run time totalization shall be incorporated for each monitored supply fan, return fan, exhaust fan, hot water and chilled water pumps. Warning limits for each point shall be entered for alarm and or maintenance purposes.
- D. Trendlog
 - 1. All binary and analog object types (including zones) shall have the capability to be automatically trended.
- E. Alarm
 - 1. All analog inputs (High/Low Limits) and selected binary input alarm points shall be prioritized and routed (locally or remotely) with alarm message per owner's requirements.

F. Database Save

1. Provide backup database for all standalone application controllers on disk.

3.6 FIELD SERVICES

- A. Prepare and start logic control system under provisions of this section.
- B. Start up and commission systems. Allow sufficient time for startup and commissioning prior to placing control systems in permanent operation.
- C. Provide the capability for off-site monitoring at control contractor's local or main office. At a minimum, off-site facility shall be capable of system diagnostics and software download. Owner shall provide phone line for this service for one (1) year or as specified.
- D. Provide owner's representative with spare parts list. Identify equipment critical to maintaining the integrity of the operating system.
- E. Commissioning: Provide a DDC technician for 50 hours who is fully trained in programming DDC systems. The technician shall also be trained in operating the installed Building Automation System. The technician shall have previous experience working with a commissioning authority to operate the BAS during testing.

3.7 AS-BUILT DOCUMENTATION REQUIRED

- A. Provide complete documentation in hardcopy (3 sets) and electronic format (searchable pdf.)
- B. Provide controls system floor plans showing the following
 1. All rooms with numbers and names for the entire building.
 2. Locations of all controlled equipment with symbol identifier based on the mechanical engineering drawings.
 3. Installed location of all control devices with device instance name and number.
 4. Tables of point to point check out of all installed devices including but not limited to the following.
 - a. LOCATION
 - b. DRAWING
 - c. DEVICE DESCRIPTION
 - d. POINT DESCRIPTION
 - e. MAC/EXP ADDRESS
 - f. DEVICE INSTANCE
 - g. POINT TYPE
 - h. POINT #
 - i. SIGNAL TYPE
 - j. UNITS MEASURED, SENSED OR CONTROLLED
 - k. CONTROL PANEL

5. Floor Plans showing wiring diagrams of all interconnecting device wiring including:
 - a. Wire runs located on floor plans
 - b. Wire run type and gauge
 - c. All equipment being controlled
 - d. Provide wiring diagram for each control panel and device placed in the enclosure the diagram describes.
6. Cut sheets for all devices.
7. Finalized Sequence of Control.
8. Operations and Maintenance data for all devices.
9. Points list.

3.8 TRAINING

- A. Provide initial walk through of project for familiarization of building, systems, and controls with BSD facilities personnel.
- B. Remaining training will be quoted as an allowance of 8 hours to be utilized by the District “as needed” for overall training.

3.9 DEMONSTRATION

- A. Demonstrate complete operating system to owner's representative.
- B. Provide certificate stating that control system has been tested and adjusted for proper operation.

PART 4 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

4.1 GENERAL

- A. Provide a complete and operational temperature control and building automation system based on the following points and sequence of operation. The system shall be complete and will meet all sequences of control and standard control practices. The determined point list is the minimum amount of points that are to be provided. If additional points are required to meet the sequence of operation, they will be provided at no extra charge to the owner.
- B. BACnet Object List
 1. The following points as defined for each piece of equipment are designated as follows:
 - a. Binary Out (BO): Defined as any two-state output (start/stop) (enable/disable), etc.
 - b. Binary In (BI): Defined as any two-state input (alarm, status), etc.
 - c. Analog In (AI): Defined as any variable input (temperature) (position), etc.
 - d. Analog Out (AO): Defined as any electrical variable output. 0–20mA, 4–20mA and 0–10VDC are the only acceptable analog outputs. The driver for analog

outputs must come from both hardware and software resident in the controllers.
Transducers will not be acceptable under any circumstance.

e. Analog Value (AV):

C. Sequence of control and controls diagrams

1. The control diagram, points list, and sequences are included on the design drawings and are listed in association with the control diagram. The control diagram, points list, and sequence of operation depict the general nature of the system control and do not indicate every device, function, mode or step in the unit operation. It is the controls contractor's responsibility working with other contractors and equipment supplier to install and program the systems and equipment to at minimum meet the sequences of control.

END OF SECTION 230923

SECTION 230923.11 - CONTROL VALVES

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 control valves and actuators for DDC systems.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
- B. Shop Drawings:
 - 1. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal:
 - 1. Schedule and design calculations for control valves and actuators, including the following:
 - a. Flow at project design and minimum flow conditions.
 - b. Pressure differential drop across valve at project design flow condition.
 - c. Maximum system pressure differential drop (pump close-off pressure) across valve at project minimum flow condition.
 - d. Design and minimum control valve coefficient with corresponding valve position.
 - e. Maximum close-off pressure.
 - f. Leakage flow at maximum system pressure differential.
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control valves to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Delegated Design: Engage a qualified professional, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.
- D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control valve actuators served from a backup power source.
- F. Determine control valve sizes and flow coefficients by ISA 75.01.01.
- G. Control valve characteristics and rangeability shall comply with ISA 75.11.01.
 - 1. Fail positions unless otherwise indicated:
 - a. Chilled Water: Close.
 - b. Heating Hot Water: Open.
 - 2. Minimum Cv shall be calculated at 10 percent of design flow, with a coincident pressure differential equal to the system design pump head.
 - 3. In water systems, select modulating control valves at terminal equipment for a design Cv based on a pressure drop of 5 psig at design flow unless otherwise indicated.

2.2 BALL-STYLE CONTROL VALVES

- A. Ball Valves with Single Port and Characterized Disk:
 - 1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
 - 2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
 - 3. Close-off Pressure: 200 psig.
 - 4. Process Temperature Range: Zero to 212 deg F.
 - 5. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
 - 6. End Connections: Threaded (NPT) ends.

7. Ball: 300 series stainless steel.
8. Stem and Stem Extension:
 - a. Material to match ball.
 - b. Blowout-proof design.
 - c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.
9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristic: Equal percentage.

B. Ball Valves with Two Ports and Characterized Disk:

1. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
2. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
3. Close-off Pressure: 200 psig.
4. Process Temperature Range: Zero to 212 deg F.
5. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
6. End Connections: Threaded (NPT) ends.
7. Ball: 300 series stainless steel.
8. Stem and Stem Extension:
 - a. Material to match ball.
 - b. Blowout-proof design.
 - c. Sleeve or other approved means to allow valve to be opened and closed without damaging the insulation or the vapor barrier seal.
9. Ball Seats: Reinforced PTFE.
10. Stem Seal: Reinforced PTFE packing ring with a threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if an equivalent cycle endurance can be demonstrated by testing.
11. Flow Characteristics for A-Port: Equal percentage.
12. Flow Characteristics for B-Port: Modified for constant common port flow.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. Commercial-Grade, Two-Way Butterfly Valves:

1. Performance:
 - a. Bi-directional bubble tight shutoff at 250 psig.
 - b. Comply with MSS SP-67 or MSS SP-68.
 - c. Rotation: Zero to 90 degrees.

- d. Linear or modified equal percentage flow characteristic.
2. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
3. Disc: 316 stainless steel.
4. Shaft: 316 or 17-4 PH stainless steel.
5. Seat: Reinforced EPDM or reinforced PTFE with retaining ring.
6. Shaft Bushings: Reinforced PTFE or stainless steel.
7. Replaceable seat, disc, and shaft bushings.
8. Corrosion-resistant nameplate indicating:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body size.
 - c. Body and trim materials.
 - d. Flow arrow.

B. Commercial-Grade, Three-Way Butterfly Valves:

1. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
2. Performance:
 - a. Bi-directional bubble tight shutoff at 250 psig.
 - b. Comply with MSS SP-67 or MSS SP-68.
 - c. Rotation: Zero to 90 degrees.
 - d. Linear or modified equal percentage flow characteristic.
3. Body: Cast iron ASTM A 126, Class B, ductile iron ASTM A 536 or cast steel ASTM A 216/A 216M WCB fully lugged, suitable for mating to ASME B16.5 flanges.
4. Disc: 316 stainless steel.
5. Shaft: 316 or 17-4 PH stainless steel.
6. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
7. Shaft Bushings: Reinforced PTFE or stainless steel.
8. Replaceable seat, disc, and shaft bushings.
9. Corrosion-resistant nameplate indicating:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body size.
 - c. Body and trim materials.
 - d. Flow arrow.

2.4 SOLENOID VALVES

A. Description:

1. Action: Either normally open or normally closed in the event of electrical power failure as required by the application.
2. Size to close against the system pressure.
3. Manual override capable.

4. Heavy-duty assembly.
5. Body: Brass or stainless steel.
6. Seats and Discs: NBR or PTFE.
7. Solenoid Enclosure: NEMA 250, Type 4.

2.5 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

- A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.
- B. Position indicator and graduated scale on each actuator.
- C. Type: Motor operated, with or without gears, electric and electronic.
- D. Voltage: Voltage selection delegated to professional designing control system.
- E. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
- F. Function properly within a range of 85 to 120 percent of nameplate voltage.
- G. Construction:
 1. For Actuators Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 2. For Actuators from 100 to 400 W: Gears ground steel, oil immersed, shaft hardened steel running in bronze, copper alloy or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel or cast-aluminum housing.
 3. For Actuators Larger Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- H. Field Adjustment:
 1. Spring Return Actuators: Easily switchable from fail open to fail closed in the field without replacement.
 2. Gear Type Actuators: External manual adjustment mechanism to allow manual positioning when the actuator is not powered.
- I. Two-Position Actuators: Single direction, spring return or reversing type.
- J. Modulating Actuators:
 1. Operation: Capable of stopping at all points across full range, and starting in either direction from any point in range.
 2. Control Input Signal:
 - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position and other input drives actuator to close position. No signal of either input remains in last position.

- b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
- c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to pulse duration (length) of signal from a dry contact closure, triac sink, or source controller.
- d. Programmable Multi-Function:
 - 1) Control Input, Position Feedback, and Running Time: Factory or field programmable.
 - 2) Diagnostic: Feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - 3) Service Data: Include, at a minimum, number of hours powered and number of hours in motion.

K. Position Feedback:

- 1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
- 2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
- 3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

L. Fail-Safe:

- 1. Where indicated, provide actuator to fail to an end position.
- 2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
- 3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

M. Integral Overload Protection:

- 1. Provide against overload throughout the entire operating range in both directions.
- 2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

N. Valve Attachment:

- 1. Unless otherwise required for valve interface, provide an actuator designed to be directly coupled to valve shaft without the need for connecting linkages.
- 2. Attach actuator to valve drive shaft in a way that ensures maximum transfer of power and torque without slippage.
- 3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

O. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

P. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with heater and control where required by application.

Q. Stroke Time:

1. Operate valve from fully closed to fully open within 60 seconds.
2. Operate valve from fully open to fully closed within 60 seconds.
3. Move valve to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.

R. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL VALVE APPLICATIONS

A. Control Valves:

1. Select from valves specified in "Control Valves" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduits to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- D. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

- E. Firestop penetrations made in fire-rated assemblies and seal penetrations made in acoustically rated assemblies.
- F. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- H. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Laboratory exhaust airstreams.
 - b. Process exhaust airstreams.
 - 3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
 - 4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 5. Where control devices are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL VALVES

- A. Install pipe reducers for valves smaller than line size. Position reducers as close to valve as possible but at distance to avoid interference and impact to performance. Install with manufacturer-recommended clearance.
- B. Install flanges or unions to allow drop-in and -out valve installation.
- C. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.
- D. Valve Orientation:
 - 1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off of vertical, not inverted.
 - 2. Install valves in a position to allow full stem movement.
 - 3. Where possible, install butterfly valves that are installed in horizontal piping with stems in horizontal position and with low point of disc opening with direction of flow.
- E. Clearance:
 - 1. Locate valves for easy access and provide separate support of valves that cannot be handled by service personnel without hoisting mechanism.
 - 2. Install valves with at least 12 inches of clear space around valve and between valves and adjacent surfaces.
- F. Threaded Valves:
 - 1. Note internal length of threads in valve ends, and proximity of valve internal seat or wall, to determine how far pipe should be threaded into valve.
 - 2. Align threads at point of assembly.
 - 3. Apply thread compound to external pipe threads, except where dry seal threading is specified.
 - 4. Assemble joint, wrench tight. Apply wrench on valve end as pipe is being threaded.
- G. Flanged Valves:
 - 1. Align flange surfaces parallel.
 - 2. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly with a torque wrench.

3.5 CONNECTIONS

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with valve identification on valve.

3.7 CHECKOUT PROCEDURES

- A. Control Valve Checkout:
 - 1. Check installed products before continuity tests, leak tests, and calibration.
 - 2. Check valves for proper location and accessibility.
 - 3. Check valves for proper installation for direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
 - 4. Verify that control valves are installed correctly for flow direction.
 - 5. Verify that valve body attachment is properly secured and sealed.
 - 6. Verify that valve actuator and linkage attachment are secure.
 - 7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 8. Verify that valve ball, disc, and plug travel are unobstructed.
 - 9. After piping systems have been tested and put into service, but before insulating and balancing, inspect each valve for leaks. Adjust or replace packing to stop leaks. Replace the valve if leaks persist.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Stroke and adjust control valves following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Stroke control valves with pilot positioners. Adjust valve and positioner following manufacturer's recommended procedure, so valve is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressures.
- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control valves equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.11

SECTION 230923.12 - CONTROL DAMPERS

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 the following types of control dampers and actuators for DDC systems:
 - 1. Rectangular control dampers.
 - 2. General control-damper actuator requirements.
 - 3. Electric and electronic actuators.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal:
 - 1. Schedule and design calculations for control dampers and actuators, including the following.
 - a. Flow at project design and minimum flow conditions.
 - b. Face velocity at project design and minimum airflow conditions.
 - c. Pressure drop across damper at project design and minimum airflow conditions.
 - d. AMCA 500D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
 - e. Maximum close-off pressure.
 - f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
 - g. Torque required at worst case condition for sizing actuator.
 - h. Actuator selection indicating torque provided.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Delegated Design: Engage a qualified professional, as defined in Section 014000 "Quality Requirements," to size products where indicated as delegated design.
- D. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- E. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.
- F. Selection Criteria:
 - 1. Select modulating dampers for a pressure drop of 2 percent of fan total static pressure unless otherwise indicated.
 - 2. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.

2.2 RECTANGULAR CONTROL DAMPERS

- A. General Requirements:
 - 1. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service, and when mixing two airstreams. For other applications, use opposed blade configuration.
 - 2. Factory assemble multiple damper sections to provide a single damper assembly of size required by the application.
- B. Rectangular Dampers with Aluminum Airfoil Blades:
 - 1. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
 - b. Pressure Drop: 0.05-in. wg at 1500 fpm across a 24-by-24-inch damper when tested according to AMCA 500-D, figure 5.3.

- c. Velocity: Up to 6000 fpm.
 - d. Temperature: Minus 40 to plus 185 deg F.
 - e. Pressure Rating: Damper close-off pressure equal to fan shutoff pressure with a maximum blade deflection of 1/200 of blade length.
 - f. Damper shall have AMCA seal for both air leakage and air performance.
2. Construction:
- a. Frame:
 - 1) Material: ASTM B 211, Alloy 6063 T5 extruded-aluminum profiles, 0.07 inch thick.
 - 2) Hat-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
 - 3) Width not less than 5 inches.
 - b. Blades:
 - 1) Hollow, airfoil, extruded aluminum.
 - 2) Parallel or opposed blade configuration as required by application.
 - 3) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.07 inch thick.
 - 4) Width not to exceed 6 inches.
 - 5) Length as required by close-off pressure, not to exceed 48 inches.
 - c. Seals:
 - 1) Blades: Replaceable, mechanically attached extruded silicone, vinyl, or plastic composite.
 - 2) Jambs: Stainless steel, compression type.
 - d. Axles: 0.5-inch-diameter stainless steel, mechanically attached to blades.
 - e. Bearings:
 - 1) Molded synthetic or stainless-steel sleeve mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
 - f. Linkage:
 - 1) Concealed in frame.
 - 2) Constructed of aluminum and stainless steel.
 - 3) Hardware: Stainless steel.
 - g. Transition:
 - 1) For round and flat oval duct applications, provide damper assembly with integral transitions to mate to adjoining field connection.
 - 2) Factory mount damper in a sleeve with a close transition to mate to field connection.
 - 3) Damper size and sleeve shall be connection size plus 2 inches.

- 4) Sleeve length shall be not less than 12 inches for dampers without jackshafts and shall be not less than 16 inches for dampers with jackshafts.
 - 5) Sleeve material shall match adjacent duct.
- h. Additional Corrosion Protection for Corrosive Environments:
 - 1) Provide anodized finish for aluminum surfaces in contact with airstream. Anodized finish shall be a minimum of 0.0007 inch thick.
 - 2) Axles, damper linkage, and hardware shall be constructed of Type 316L stainless steel.
- 3. Airflow Measurement:
 - a. Where indicated, provide damper assembly with integral airflow monitoring.
 - b. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
 - c. Accuracy shall be within 5 percent of the actual flow rate between the range of minimum and design airflow. For applications with a large variation in range between the minimum and design airflow, configure the damper sections and flow measurement assembly as required to comply with the stated accuracy over the entire modulating range.
 - d. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
 - e. Suitable for operation in untreated and unfiltered air.
 - f. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - g. Provide automatic zeroing feature.

2.3 GENERAL CONTROL-DAMPER ACTUATORS REQUIREMENTS

- A. Actuators shall operate related damper(s) with sufficient reserve power to provide smooth modulating action or two-position action and proper speed of response at velocity and pressure conditions to which the damper is subjected.
- B. Actuators shall produce sufficient power and torque to close off against the maximum system pressures encountered. Actuators shall be sized to close off against the fan shutoff pressure as a minimum requirement.
- C. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
- D. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
- E. Avoid the use of excessively oversized actuators which could overdrive and cause linkage failure when the damper blade has reached either its full open or closed position.
- F. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.

- G. Provide mounting hardware and linkages for connecting actuator to damper.
- H. Select actuators to fail in desired position in the event of a power failure.

2.4 ELECTRIC AND ELECTRONIC ACTUATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Belimo
- B. Type: Motor operated, with or without gears, electric and electronic.
- C. Voltage:
 - 1. Voltage selection is delegated to professional designing control system.
 - 2. Actuator shall deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
 - 3. Actuator shall function properly within a range of 85 to 120 percent of nameplate voltage.
- D. Construction:
 - 1. Less Than 100 W: Fiber or reinforced nylon gears with steel shaft, copper alloy or nylon bearings, and pressed steel enclosures.
 - 2. 100 up to 400 W: Gears ground steel, oil immersed, shaft-hardened steel running in bronze, copper alloy, or ball bearings. Operator and gear trains shall be totally enclosed in dustproof cast-iron, cast-steel, or cast-aluminum housing.
 - 3. Greater Than 400 W: Totally enclosed reversible induction motors with auxiliary hand crank and permanently lubricated bearings.
- E. Field Adjustment:
 - 1. Spring return actuators shall be easily switchable from fail open to fail closed in the field without replacement.
 - 2. Provide gear-type actuators with an external manual adjustment mechanism to allow manual positioning of the damper when the actuator is not powered.
- F. Two-Position Actuators: Single direction, spring return or reversing type.
- G. Modulating Actuators:
 - 1. Capable of stopping at all points across full range, and starting in either direction from any point in range.
 - 2. Control Input Signal:
 - a. Three Point, Tristate, or Floating Point: Clockwise and counter-clockwise inputs. One input drives actuator to open position, and other input drives actuator to close position. No signal of either input remains in last position.

- b. Proportional: Actuator drives proportional to input signal and modulates throughout its angle of rotation. Suitable for zero- to 10- or 2- to 10-V dc and 4- to 20-mA signals.
- c. Pulse Width Modulation (PWM): Actuator drives to a specified position according to a pulse duration (length) of signal from a dry-contact closure, triac sink or source controller.
- d. Programmable Multi-Function:
 - 1) Control input, position feedback, and running time shall be factory or field programmable.
 - 2) Diagnostic feedback of hunting or oscillation, mechanical overload, mechanical travel, and mechanical load limit.
 - 3) Service data, including at a minimum, number of hours powered and number of hours in motion.

H. Position Feedback:

- 1. Equip two-position actuators with limits switches or other positive means of a position indication signal for remote monitoring of open and close position.
- 2. Equip modulating actuators with a position feedback through current or voltage signal for remote monitoring.
- 3. Provide a position indicator and graduated scale on each actuator indicating open and closed travel limits.

I. Fail-Safe:

- 1. Where indicated, provide actuator to fail to an end position.
- 2. Internal spring return mechanism to drive controlled device to an end position (open or close) on loss of power.
- 3. Batteries, capacitors, and other non-mechanical forms of fail-safe operation are acceptable only where uniquely indicated.

J. Integral Overload Protection:

- 1. Provide against overload throughout the entire operating range in both directions.
- 2. Electronic overload, digital rotation sensing circuitry, mechanical end switches, or magnetic clutches are acceptable methods of protection.

K. Damper Attachment:

- 1. Unless otherwise required for damper interface, provide actuator designed to be directly coupled to damper shaft without need for connecting linkages.
- 2. Attach actuator to damper drive shaft in a way that ensures maximum transfer of power and torque without slippage.
- 3. Bolt and set screw method of attachment is acceptable only if provided with at least two points of attachment.

L. Temperature and Humidity:

1. Temperature: Suitable for operating temperature range encountered by application with minimum operating temperature range of minus 20 to plus 120 deg F.
2. Humidity: Suitable for humidity range encountered by application; minimum operating range shall be from 5 to 95 percent relative humidity, non-condensing.

M. Enclosure:

1. Suitable for ambient conditions encountered by application.
2. NEMA 250, Type 2 for indoor and protected applications.
3. NEMA 250, Type 4 or Type 4X for outdoor and unprotected applications.
4. Provide actuator enclosure with a heater and controller where required by application.

N. Stroke Time:

1. Operate damper from fully closed to fully open within 60 seconds.
2. Operate damper from fully open to fully closed within 60 seconds.
3. Move damper to failed position within 15 seconds.
4. Select operating speed to be compatible with equipment and system operation.
5. Actuators operating in smoke control systems comply with governing code and NFPA requirements.

O. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

PART 3 - EXECUTION

3.1 CONTROL-DAMPER APPLICATIONS

A. Control Dampers:

- B. Select from damper types indicated in "Control Dampers" Article to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy most stringent requirements indicated.
- B. Properly support dampers and actuators, tubing, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- C. Provide ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that

could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.

- D. Seal penetrations made in fire-rated and acoustically rated assemblies.
- E. Fastening Hardware:
 - 1. Stillson wrenches, pliers, or other tools that will cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- F. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- G. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Laboratory exhaust airstreams.
 - b. Process exhaust airstreams.
 - 3. Use Type 316 stainless-steel tubing and fittings when in contact with a corrosive environment.
 - 4. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 5. Where actuators are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 CONTROL DAMPERS

- A. Install smooth transitions, not exceeding 30 degrees, to dampers smaller than adjacent duct. Install transitions as close to damper as possible but at distance to avoid interference and impact to performance. Consult manufacturer for recommended clearance.
- B. Clearance:
 - 1. Locate dampers for easy access and provide separate support of dampers that cannot be handled by service personnel without hoisting mechanism.
 - 2. Install dampers with at least 24 inches of clear space on sides of dampers requiring service access.
- C. Service Access:
 - 1. Dampers and actuators shall be accessible for visual inspection and service.
 - 2. Install access door(s) in duct or equipment located upstream of damper to allow service personnel to hand clean any portion of damper, linkage, and actuator. Comply with requirements in Section 233300 "Air Duct Accessories."
- D. Install dampers straight and true, level in all planes, and square in all dimensions. Install supplementary structural steel reinforcement for large multiple-section dampers if factory support alone cannot handle loading.
- E. Attach actuator(s) to damper drive shaft.
- F. For duct-mounted and equipment-mounted dampers installed outside of equipment, install a visible and accessible indication of damper position from outside.

3.5 CONNECTIONS

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with damper identification on damper.

3.7 CHECKOUT PROCEDURES

- A. Control-Damper Checkout:
 - 1. Check installed products before continuity tests, leak tests, and calibration.

2. Check dampers for proper location and accessibility.
3. Verify that control dampers are installed correctly for flow direction.
4. Verify that proper blade alignment, either parallel or opposed, has been provided.
5. Verify that damper frame attachment is properly secured and sealed.
6. Verify that damper actuator and linkage attachment are secure.
7. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
8. Verify that damper blade travel is unobstructed.

3.8 ADJUSTMENT, CALIBRATION, AND TESTING:

- A. Stroke and adjust control dampers following manufacturer's recommended procedure, from 100 percent open to 100 percent closed back to 100 percent open.
- B. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- C. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION 230923.12

SECTION 230923.13 - ENERGY METERS

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 thermal and electric power energy meters that connect to DDC systems.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product Data: For continuous metering equipment for energy consumption.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each product requiring a certificate.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 THERMAL ENERGY METERS

- A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.

1. Product certificates are required.

- B. In-Line, Compact-Type Thermal Energy Meters: Requirements in remaining subparagraphs are based on Onicon's "System 30 Series."

1. Description:

- a. Factory-packaged meter consisting of supply and return temperature sensors, flow sensor, digital display, operator interface, installation hardware, interconnecting cabling, and installation instructions.
- b. Each thermal energy meter shall be individually calibrated and provided with calibration certifications traceable to NIST.
- c. Meter limited to flow rates between 0.8 and 38 gpm.
- d. Meter mode of operation shall be field configurable to accommodate two pipe systems that change from between heating and cooling.

2. Alphanumeric display of the following on face of enclosure:

- a. Total energy consumption.
- b. Energy rate.
- c. Flow rate.
- d. Supply temperature.
- e. Return temperature.

3. Diagnostic Lights:

- a. Meter equipped with diagnostic indicator lights that confirm the operation of the microprocessor and its input circuitry.
- b. Red LED labeled "BTU" shall flash as energy is transferred.
- c. Red LED labeled "FLOW" shall flash at a rate that is proportional to the liquid flow rate. An unlit LED indicates no flow signal.

4. Programming:

- a. Meter shall be factory programmed for specific application.
- b. Programmed parameters and total energy consumption shall be stored in non-volatile memory.

5. Output Signals:

- a. Mode 1 and Mode 2 Total Energy Consumption: Isolated solid-state dry contact with 100 mA, 50-V rating and contact duration of 0.5, 1, 2, or 6 seconds.

- b. Factory-set isolated analog output for energy rate, flow rate, or temperature difference: 4 to 20 mA, zero to 5 or 10 V.
 - c. In lieu of hardwired output signals, a serial communication interface may be used.
- 6. Serial Communication Interface: Compatible with host to share total energy consumption, energy rate, flow rate, and supply and return temperature data.
- 7. Temperature Sensors:
 - a. Temperature range matched to application.
 - b. Differential temperature accuracy within 0.15 deg F over the calibrated range.
 - c. One temperature sensor shall be built into the body of the flow sensor.
 - d. Second sensor shall be provided with brass thermowell with NPS 1/2 sweat fitting or NPS 1/4 NPT connection.
- 8. Flow Sensor:
 - a. Ambient Temperature: 40 to 120 deg F.
 - b. Process Temperature: 32 to 200 deg F.
 - c. Maximum Process Pressure: 400 psig.
 - d. Pressure Drop: 3 psig at 38 gpm.
 - e. Accuracy:
 - 1) Within 1 percent of actual flow over flow rate range of 5.7 to 38 gpm.
 - 2) Within 2 percent of actual flow over flow rate range of 0.8 to 38 gpm.
 - 3) Within 0.5 percent of actual reading at the calibrated velocity.
 - f. Construct flow sensor body of brass.
 - g. Furnish with two tail pieces to facilitate connection to the piping system. One end of each tail piece shall be a compression fitting with retaining nut, and the other end shall either be a sweat fitting for copper or a threaded nipple with NPT threads.
 - h. Process Connections: NPS 3/4 or NPS 1.
 - i. House electronics in a NEMA 250, Type 4 weathertight aluminum enclosure with a gasketed cover. Housing shall include connection for field-installed conduit.
 - j. Sensor cable length shall be sufficient to connect to display module.
- 9. Power Supply:
 - a. Field Power: 24-V ac, 50 or 60 Hz unless otherwise required by the application.

2.2 ELECTRIC POWER METERS

- A. Performance Requirements: Manufacturer shall certify that each energy meter indicated complies with specified performance requirements and characteristics.
 - 1. Product certificates are required.
- B. Multifunction Electric Power Meter:
 - 1. Hardware:

- a. Voltage Inputs: Three voltage inputs capable of measuring from zero- to 400-V rms (line to neutral) or from zero- to 690-V rms (line to line). The instrument shall have provisions for direct connection for wye (Star) systems up to 347/600-V ac. For higher-voltage systems, PTs with 120-, 277-, or 347-V ac secondaries shall be supported. Voltage inputs shall provide the following:
 - 1) 1500-V ac continuous surge protection.
 - 2) 25 percent of full-scale voltage over range capability.
- b. Current Inputs: Three 5-A nominal (6-A full-scale) current inputs. Current inputs shall be transformer coupled and accept CTs with 5-A nominal (6-A full-scale) outputs. Current inputs shall provide the following:
 - 1) 120-A surge protection for one second.
 - 2) 20 percent of nominal current continuous over range capability.
- c. Power Supply: 100- to 240-V ac (within 10 percent) at 50 to 60 Hz, 110- to 300-V dc, or 20- to 60-V dc power source. Load shall not exceed 15 W.
- d. Onboard I/O:
 - 1) Two Form A solid-state digital (status) outputs with the following features:
 - a) The ability to be used to provide pulse outputs according to any energy consumption levels.
 - b) Rated 200-V ac/dc with a maximum current of 100 mA.
- e. Communications:
 - 1) Provide the following built-in communication ports of standard technology, as defined by the IEEE:
 - a) One optically isolated RS-485 communication port, supporting data rates from 1200 to 19200 bits per second.
 - 2) Communication ports shall support the following communication capabilities, independently configurable:
 - a) PML protocol.
 - b) Modbus RTU protocol.
 - c) Shall provide simultaneous access through all communication ports to any measured or derived parameter.
 - d) Protocols shall be field configurable from the front display, or via communication ports, and be capable of being accomplished without resetting the meter or interrupting its operation in any way.
 - e) Support time synchronization broadcast messages from a host computer system.
- f. Mounting and Display:
 - 1) The instrument shall support the following mounting options:

- a) 3.6-by-3.6-inch panel cutout, using sliding clamps tightened by thumbscrews.
 - b) ANSI 4-inch round cut-out.
 - c) Transducer-type base unit with a remote LED display with cable for remote display applications.
 - d) Transducer-type base unit only with no display locally mounted.
 - e) Allow the operator to remove and replace the display panel without removing the instrument from the equipment in which it is mounted.
 - g. Enclosure: If installation requires meter to be installed in a dedicated enclosure, install meter in an NRTL-listed enclosure suitable for operating environment at meter location.
 - 1) Indoors: NEMA 250, Type 2.
 - 2) Outdoors: NEMA 250, Type 4X.
 - h. Memory: Sufficient non-volatile (RAM) to store setup data and accumulated energy values.
2. The instrument shall measure and calculate the following information:
- a. Voltage line-to-neutral and line-to-line for each phase and average of three phases.
 - b. Current for each phase and average of three phases.
 - c. Peak current demand.
 - d. Neutral current.
 - e. Power (kW).
 - f. Peak power demand (kW).
 - g. Energy (kWh) import/export.
 - h. Power factor total.
 - i. Frequency.
3. Operator interface features are as follows:
- a. Capable of calculating the following information for any reading at one-second intervals:
 - 1) Sliding window demands for any parameter with operator-programmable length of demand period and number of subperiods to match local utility billing method.
 - b. Support direct display of all parameters on the front panel or remote display in user-programmable groups, using plain language labels. Simultaneous access to all parameters shall be available through any communication port.
 - c. Field programmable as follows:
 - 1) Basic Parameters: Voltage input scale, voltage mode (wye, delta, single phase), current input scale, auxiliary input and output scales, and communication setup parameters are programmable from the front panel.

- 2) Using ION modules, support customized configurations of all operating parameters.
- 3) Provisions to ensure that programming through a computer can be secured by user ID and password.
- 4) Provisions to ensure that programming through the front panel is secured by password.
- 5) Digital outputs shall support pulse output relay operation for kWh total, kWh imported, kWh exported, kVARh total, kVARh imported, kVARh exported, and kVAh values.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- C. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

3.2 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices. Refer to Division 01 Section 017900 "Demonstration and Training."

END OF SECTION 230923.13

SECTION 230923.14 - FLOW INSTRUMENTS

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. Airflow sensors.
2. Airflow switches.
3. Airflow transmitters.
4. Liquid flow meters.
5. Liquid flow sensors.
6. Liquid flow switches.
7. Liquid flow transmitters.

- B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

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

- B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

- C. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include diagrams for power, signal, and control wiring.
3. Include diagrams for air and process signal tubing.
4. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

- D. Delegated-Design Submittal:

1. Schedule and design calculations for flow instruments, including the following.

- a. Flow at Project design and minimum flow conditions.
- b. Pressure drop at Project design and minimum flow conditions.

1.4 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each product requiring a certificate.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Select and size products to achieve specified performance requirements.
- B. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 GENERAL REQUIREMENTS FOR FLOW INSTRUMENTS

- A. Air sensors and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below minimum Project flow to signal abnormal flow conditions and to provide flexibility for changes in operation.
- B. Liquid and steam sensors, meters, and transmitters shall have an extended range of 20 percent above Project design flow and 20 percent below Project minimum flow to signal abnormal flow conditions and to provide flexibility for changes in operation.

2.3 AIRFLOW SENSORS:

- A. Performance Requirements:
 - 1. Adjustable for changes in system operational parameters.
 - 2. Manufacturer shall certify that each flow instrument indicated complies with specified performance requirements and characteristics.
 - a. Product certificates are required.
- B. Thermal Airflow Station:
 - 1. Source Limitations: Obtain airflow and temperature measuring sensors and transmitters from single manufacturer.

2. Description: Airflow station shall consist of one or more sensor probes mounted in a casing, and a remotely mounted microprocessor-based transmitter.
3. Performance:
 - a. Capable of independently processing up to 16 independently wired sensor assemblies.
 - b. Airflow rate of each sensor assembly shall be equally weighted and averaged by transmitter prior to output.
 - c. Temperature of each sensor assembly shall be velocity weighted and averaged by transmitter prior to output.
 - d. Listed and labeled by an NRTL as successfully tested as an assembly according to UL 873, "Temperature-Indicating and Regulating Equipment."
 - e. Components shall be interconnected by exposed NRTL-listed plenum-rated cable or non-listed cable placed in conduit.
 - f. Each flow station shall be factory calibrated at a minimum of 16 airflow rates and temperatures to standards that are traceable to NIST.
 - g. Airflow Accuracy: Within 2 percent of reading over the entire operating airflow range.
 - 1) Devices whose accuracy is combined accuracy of transmitter and sensor probes must demonstrate that total accuracy meets the performance requirements throughout the measurement range.
 - h. Temperature Accuracy: Within 0.2 deg F over entire operating range of minus 20 to plus 140 deg F.
 - i. Sensor Ambient Operating Temperature Range: Minus 20 to plus 160 deg F.
 - j. Transmitter Ambient Operating Temperature Range: Minus 20 to plus 120 deg F.
 - k. Sensor and Transmitter Ambient Operating Humidity Range: Zero to 99 percent, non-condensing.
 - l. Instrument shall compensate for changes in air temperature and density throughout calibrated velocity range for seasonal extremes at Project location.
 - m. Pressure Drop: 0.05-inch wg at 2000 fpm across a 24-by-24-inch area.
 - n. Instruments mounted in throat or face of fan inlet cone shall not negatively influence fan performance by reducing flow more than 1 percent of Project design flow or negatively impact fan-generated sound. Losses in performance shall be documented with submittal data, and adjustments to compensate for performance impact shall be made to fan in order to deliver Project design airflow indicated.
4. Sensor Assemblies:
 - a. Each sensor probe shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
 - b. Mount thermistors in sensor using a marine-grade, waterproof epoxy.
 - c. Thermistor leads shall be protected and not exposed to the environment.
 - d. Each sensor assembly shall independently determine airflow rate and temperature at each measurement point.
 - e. Each sensor probe shall have an integral cable for connection to remotely mounted transmitter.
 - f. Sensor Probe Material: Gold anodized, extruded 6063 aluminum tube or Type 304 stainless steel.

- g. Probe Assembly Mounting Brackets Material: Type 304 stainless steel.

5. Casing:

- a. Factory mount sensor probes in an airflow station casing to create a single assembly for field mounting.
- b. Material: Galvanized sheet steel at least 0.079 inch thick with coating complying with ASTM A 653/A 653M, G90. Casings shall be stainless steel, 0.0781 inch thick, when connected to stainless duct and aluminum, 0.063 inch thick, when connected to aluminum duct.
- c. Joints and Seams: Continuously weld. Clean galvanized areas damaged by welding and coat with zinc-rich paint.
- d. Casing Depth: At least 8 inches.
- e. Include casing inlet and discharge connections with a minimum 1.5-inch face flange.

6. Transmitter:

- a. Integral digital display capable of simultaneously displaying total airflow and average temperature, individual airflow, and temperature readings of each independent sensor assembly.
- b. Capable of field configuration and diagnostics using an onboard push-button interface and digital display.
 - 1) Include an integral power switch to operate on 24-V ac (isolation not required) and include the following:
 - a) Integral protection from transients and power surges.
 - b) Circuitry to ensure reset after power disruption, transients, and brownouts.
 - c) Integral transformer to convert field power source to operating voltage required by instrument.
- c. Remote Signal Interface:
 - 1) RS-485: BACnet-ARCNET, BACnet-MS/TP, and Modbus-RTU.

2.4 AIRFLOW SWITCHES

A. Stainless-Steel Single Vane Switch:

1. Description:

- a. Velocities up to 2000 fpm.
- b. Suitable for mounting with air direction in horizontal.

2. Performance:

- a. Voltage: 125-, 240-, and 480-V ac.

- b. Full Load Current: 9.8 A at 125-V ac.
 - c. Field-Adjustable Velocity Set Point: 400 to 1600 fpm.
 - d. Maximum Process Temperature: 180 deg F.
 - e. Maximum Ambient Temperature: 125 deg F.
- 3. Construction:
 - a. Stainless-steel vane.
 - b. Vane actuates a SPDT snap switch.
 - c. Enclosure Material: Die-cast metal.
 - d. Enclosure with removable cover.
 - e. NEMA 250, Type 1 enclosure.
 - f. Screw set-point adjustment.
 - g. Electrical Connections: Screw terminals.
 - h. Conduit Connections: 1-inch trade size conduit knock outs on top and bottom.

2.5 AIRFLOW TRANSMITTERS

A. Airflow Transmitters with 0.25 Percent Accuracy and Auto-Zero Feature:

- 1. Transmitter shall receive total- and static-pressure signals from a flow element, amplify signals, extract the square foot, and scale the signals to produce 4- to 20-mA dc output signals linear to airflow.
- 2. NEMA 250, Type 1 enclosure.
- 3. Construct assembly so shock, vibration, and pressures surges of up to 1 psig will neither harm transmitter, nor affect its accuracy.
- 4. Transmitter with automatic zeroing circuit capable of automatically readjusting transmitter zero at predetermined time intervals. The automatic zeroing circuit shall re-zero the transmitter to within 0.1 percent of true zero.
- 5. Performance:
 - a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
 - b. Calibrated Span: Field adjustable, minus 40 percent of the range.
 - c. Accuracy: Within 0.25 percent of natural span.
 - d. Repeatability: Within 0.15 percent of calibrated span.
 - e. Linearity: Within 0.2 percent of calibrated span.
 - f. Hysteresis and Deadband (Combined): Less than 0.2 percent of calibrated span.
- 6. Integral digital display for continuous indication of airflow.

B. Pressure Differential Transmitters for Airflow Measurement:

- 1. Performance:
 - a. Range: As required by application and at least 10 percent below minimum airflow and 10 percent greater than design airflow.
 - b. Accuracy: Within 0.5 percent of the full-scale range.
 - c. Hysteresis: Within 0.10 percent of full scale.

- d. Repeatability: Within 0.05 percent of full scale.
 - e. Stability: Within one percent of span per year.
 - f. Overpressure: 10 psig.
 - g. Temperature Limits: Zero to 150 deg F.
 - h. Compensate Temperature Limits: 40 to 150 deg F.
 - i. Thermal Effects: 0.033 percent of full scale per degree F.
 - j. Shock and vibration shall not harm the transmitter.
2. Output Signals:
- a. Analog Current Signal:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 800-ohm load.
3. Display: Four-digit digital with minimum 0.4-inch-high numeric characters.
4. Operator Interface:
- a. Zero and span adjustments located behind cover.
5. Construction:
- a. Plastic casing with removable plastic cover.
 - b. Fittings: Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on bottom of instrument case.
 - c. Screw terminal block for wire connections.
 - d. Vertical plane mounting.
 - e. NEMA 250, Type 4.
 - f. Mounting Bracket: Appropriate for installation.

2.6 ELECTROMAGNETIC FLOWMETERS

A. Inline Electromagnetic Flow Meters

- 1. Description: Inline Electromagnetic Flow Meter complete with integral or remote transmitter.
- 2. Accuracy: $\pm 0.2\%$ of reading from 3.3–33 ft/s, $\pm 0.75\%$ of reading from 1–3.3 ft/s, ± 0.0075 ft/s at flows less than 1 ft/s
- 3. Construction: Epoxy coated steel flow tube; 316SS sensing electrodes; polypropylene or ebonite liner for low temperature service, PTFE liner for hot water service (302°F maximum).
- 4. Ratings:
 - a. Pressure: ANSI Class 150 Flange
 - b. Temperature: 0–300°F
- 5. Output: Isolated 4–20mA analog output for flow rate and two programmable digital/pulse outputs (configurable for frequency, pulse or directional flow)
- 6. Display - Backlit 16 character, 8 line graphic LCD displays: flow rate and velocity, flow direction and totals, short term trend data and error messages.
- 7. A certificate of calibration shall be provided with each flow meter.
- 8. Manufacturer:
 - a. ONICON F-3000 Series

- b. Or approved equal.

B. Insertion Electromagnetic Flow Meters

1. Description: Insertion Turbine Flow Meter complete with all installation hardware necessary (branch outlet, close nipple, and full-port ball valve) to enable insertion and removal of the flow meter without system shutdown.
2. Accuracy: $\pm 1.0\%$ of reading from 2–20 ft/sec and ± 0.02 ft/sec below 2 ft/sec
3. Construction: The flow sensor shall be constructed of plated brass (or 316 stainless steel as required by the application), with standard features to include a weather-tight electronics enclosure and half inch conduit connection fitting. The turbine elements shall be made of polypropylene or polysulfone with sapphire jewel bearings and tungsten carbide shafts.
4. Ratings:
 - a. Pressure: 400 psig.
 - b. Temperature: 250 F.
5. Output Signals Provided: 4–20mA, 0–10V or 0–5V, scalable pulse output
6. Display: Optional remote visual instantaneous rate of flow and totalized flow.
7. A certificate of calibration shall be provided with each flow meter.
8. Manufacturer:
 - a. ONICON F-3500 Series
 - b. Or approved equal.

2.7 LIQUID FLOW SWITCHES

A. Liquid Flow Switch (Bellows Type):

1. Description:
 - a. Field-adjustable four-vane combinations.
 - b. Field-adjustable set-point adjustment screw.
 - c. Suitable for pipe sizes NPS 1 through NPS 8.
 - d. Switch mounted vertically in horizontal pipe.
2. Performance:
 - a. Flow Rate Actuation and De-actuation: Varies with vane combination and set-point adjustment.
 - b. Pressure Limit: 145 psig.
 - c. Temperature Limit: 230 deg F.
 - d. Electrical Rating: 10 A resistive, 3 A conductive at 250-V ac.
 - e. Switch Type: SPDT snap switch.
3. Wetted Parts Construction:
 - a. Bellows: Tin-bronze.
 - b. Vanes: Stainless steel.
 - c. Body: Forged brass.

- d. Process Connection: NPS 1.
- 4. Enclosure:
 - a. Die-cast aluminum alloy.
 - b. NEMA 250, Type 4.
 - c. Electrical Connection: Cable gland with attached wire leads.

2.8 LIQUID FLOW TRANSMITTERS

A. Liquid Pressure Differential Transmitter for Flow Measurement:

- 1. Performance:
 - a. Range: Approximately 2 times the set point.
 - b. Span: Adjustable plus or minus 1 mA, non-interactive.
 - c. Accuracy: Within 0.25 percent of full scale.
 - d. Maximum Operating Pressure: 2.5 times range.
 - e. Temperature Limits: Zero to 175 deg F.
 - f. Compensate Temperature Limits: 30 to 150 deg F.
 - g. Thermal Effects: 0.02 percent of full scale per degree F.
 - h. Response Time: 30 to 50 ms.
 - i. Shock and vibration shall not harm the transmitter.
- 2. Analog Output Current Signal:
 - a. Two wire, 4- to 20-mA dc current source.
 - b. Signal capable of operating into 1000-ohm load.
- 3. Operator Interface:
 - a. Zero and span adjustments located behind cover.
 - b. Bleed screws on side of body, two screws on low-pressure side and one screw on high-pressure side, for air in line and pressure cavity.
- 4. Construction:
 - a. Aluminum and stainless-steel enclosure with removable cover.
 - b. Wetted parts of transmitter constructed of 17-4 PH or 300 series stainless steel.
 - c. NPS 1/4 process connections on side of instrument enclosure.
 - d. Knock out for 1/2-inch trade size conduit connection on side of instrument enclosure.
 - e. Screw terminal block for wire connections.
 - f. NEMA 250, Type 4X.
 - g. Mounting bracket shall be suitable for installation.
- 5. Transmitter shall have three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have NPS 1/4 process connections.

PART 3 - EXECUTION

3.1 INSTRUMENT APPLICATIONS

- A. Select from instrument types to achieve performance requirements and characteristics indicated while subjected to full range of system operation encountered.
- B. Duct-Mounted Airflow Sensors:
 - 1. Measured Velocities 500 fpm and Less: Thermal airflow station.
 - 2. Measured Velocities Greater than 500 fpm: Thermal airflow station.
- C. Damper-Mounted Airflow Sensors:
 - 1. Measured Velocities 500 fpm and Less: Thermal airflow station.
 - 2. Measured Velocities Greater than 500 fpm: Thermal airflow station.
- D. Fan-Mounted Airflow Sensors:
 - 1. Measured Velocities 500 fpm and Less: Thermal airflow station.
 - 2. Measured Velocities Greater than 500 fpm: Thermal airflow station.
- E. Airflow Switches:
 - 1. Measured Velocities Greater than 25 fpm Stainless-steel single-vane switch.

3.2 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- D. Install ceiling, floor, roof, and wall openings and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- E. Install products in locations that are accessible and that will permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they will be subjected.

2. If possible, avoid or limit use of materials in corrosive environments, including, but not limited to, the following:
 - a. Process exhaust airstreams.
3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

- A. Mounting Location:
 1. Rough-in: Outline instrument-mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
 2. Install switches and transmitters for air and liquid flow associated with individual air-handling units and connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid and steam flow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install airflow switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
 6. Install instruments in steam, liquid, and liquid-sealed-piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.

7. Install instruments in dry gas and non-condensable-vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
2. Mount switches and transmitters, located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements, within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.

- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.5 FLOW INSTRUMENTS INSTALLATION

A. Airflow Sensors:

1. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
2. Installed sensors shall be accessible for visual inspection and service. Install access door(s) in duct or equipment located upstream of sensor, to allow service personnel to hand clean sensors.

B. Liquid and Steam Sensors:

1. Install sensors in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Alert manufacturer where installation cannot accommodate recommended clearance, and solicit recommendations for field modifications to installation, such as flow straighteners, to improve condition.
3. Install pipe reducers for in-line sensors smaller than line size. Position reducers at distance from sensor to avoid interference and impact on accuracy.
4. Install in-line sensors with flanges or unions to provide drop-in and -out installation.

C. Liquid Flow Meters:

1. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
2. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
3. Install in-line meters with flanges or unions to provide drop-in and -out installation.
4. Insertion Meters:

- a. Install system process connections full size of meter connection, but not less than NPS 1. Provide bushing if required to mate to system connection.
- b. Install meter in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
- c. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

D. Liquid Switches:

1. Install system process connection full size of switch connection, but not less than NPS 1. Install bushing if required to mate switch to system connection.
2. Install switch in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement.
3. In applications where top-dead-center location is not possible due to field constraints, install switch at location along top half of pipe if switch is acceptable by manufacturer for mounting orientation.

E. Transmitters:

1. Install airflow transmitters serving an air system in a single location adjacent to or within system control panel.
2. Install liquid flow transmitters, not integral to sensors, in vicinity of sensor. Where multiple flow transmitters serving same system are located in same room, co-locate transmitters by system to provide service personnel a single and convenient location for inspection and service.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

3.7 CHECKOUT PROCEDURES

A. Description:

1. Check out installed products before continuity tests, leak tests, and calibration.
2. Check instruments for proper location and accessibility.
3. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that will impact performance.
4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

B. Flow Instrument Checkout:

1. Verify that sensors are installed correctly with respect to flow direction.
2. Verify that sensor attachment is properly secured and sealed.
3. Verify that processing tubing attachment is secure and isolation valves have been provided.
4. Inspect instrument tag against approved submittal.
5. Verify that recommended upstream and downstream distances have been maintained.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices. Refer to Division 01 Section 017900 "Demonstration and Training."

END OF SECTION 230923.14

SECTION 230923.16 - GAS INSTRUMENTS

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 the Following Gas Instruments:
 - 1. Carbon-dioxide sensors and transmitters.
 - 2. VOC sensors and transmitters.
- B. Related Requirements:
 - 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
- C. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

A. Description:

1. NDIR technology or equivalent technology providing long-term stability and reliability.
2. Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

B. Construction:

1. House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
2. Equip with digital display for continuous indication of carbon-dioxide concentration.

C. Performance:

1. Measurement Range: Zero to 2000 ppm.
2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
3. Repeatability: Within 1 percent of full scale.
4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F.
5. Long-Term Stability: Within 5 percent of full scale after more than five years.
6. Response Time: Within 60 seconds.
7. Warm-up Time: Within five minutes.

D. Provide calibration kit. Turn over to Owner at start of warranty period.

2.2 VOC SENSORS

A. Description:

1. VOC sensor shall use an oxidizing element that varies resistance with contaminant gases.
2. Senses and responds to combined concentration of more than 30 contaminants commonly found in indoor environments.

B. Output Signal: Zero to 5 or 10-V dc with minimum load resistance of 4000 ohms.

C. Performance:

1. Measurement Range: Zero to 100 percent.
2. Ambient Temperature: 32 to 140 deg F.
3. Ambient Relative Humidity: 5 to 95 percent non-condensing.

D. Enclosure: Lexan.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Furnish and install products required to satisfy more stringent of all requirements indicated.
- B. Install products level, plumb, parallel, and perpendicular with building construction.
- C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.
- D. Fastening Hardware:
 - 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 - 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 - 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 - 1. Use products that are suitable for environment to which they are subjected.
 - 2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:
 - a. Laboratory exhaust airstreams.
 - b. Process exhaust airstreams.
 - 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 - 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

- 1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
- 2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
- 3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- 4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.

B. Mounting Height:

- 1. Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
- 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.

- C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification on face.

3.5 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices. Refer to Division 01 Section 017900 "Demonstration and Training."

END OF SECTION 230923.16

SECTION 230923.23 - PRESSURE INSTRUMENTS

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. Air-pressure sensors.
2. Air-pressure switches.
3. Air-pressure transmitters.
4. Liquid-pressure switches.
5. Liquid-pressure transmitters.

- B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 AIR-PRESSURE SENSORS

- A. Duct Insertion Static Pressure Sensor:

- 1. Insertion length shall be at 6 inches.
- 2. Sensor with four radial holes of 0.04-inch diameter.
- 3. Brass or stainless-steel construction.
- 4. Sensor with threaded end support, sealing washers and nuts.
- 5. Connection: NPS 1/4 compression fitting.
- 6. Suitable for flat oval, rectangular, and round duct configurations.

- B. Outdoor Static Pressure Sensor:

- 1. Provides average outdoor pressure signal.
- 2. Sensor with no moving parts.
- 3. Kit includes sensor, vinyl tubing mounting hardware.

- C. Space Static Pressure Sensor for Wall Mounting:

- 1. 100-micron filter mounted in stainless-steel wall plate senses static pressure.
- 2. Wall plate provided with gasket and screws, and sized to fit standard single-gang electrical box.
- 3. Back of sensor plate fitted with brass barbed fitting for tubing connection.

- D. Space Static Pressure Sensor for Recessed Ceiling Mounting:

- 1. Aluminum round plate with perforated center arranged to sense space static pressure. Exposed surfaces provided with brush finish.
- 2. Sensor intended for flush mount on face of ceiling with pressure chamber recessed in ceiling plenum.
- 3. Back of sensor plate fitted with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, and 0.125-inch fitting for concealed tubing connection.
- 4. Performance: Within 1 percent of actual room static pressure in vicinity of sensor while being subjected to an air velocity of 1000 fpm from a 360-degree radial source.

2.2 AIR-PRESSURE SWITCHES

- A. Air-Pressure Differential Switch:

- 1. Diaphragm operated to actuate an SPDT snap switch.

- a. Fan safety shutdown applications: Switch with manual reset.
2. Electrical Connections: Three-screw configuration, including one screw for common operation and two screws for field-selectable normally open or closed operation.
3. Enclosure Conduit Connection: Knock out or threaded connection.
4. User Interface: Screw-type set-point adjustment located inside removable enclosure cover.
5. High and Low Process Connections: Threaded, NPS 1/8.
6. Enclosure:
 - a. Dry Indoor Installations: NEMA 250, Type 1.
 - b. Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - c. Hazardous Environments: Explosion proof.
7. Operating Data:
 - a. Electrical Rating: 15 A at 120- to 480-V ac.
 - b. Pressure Limits:
 - 1) Continuous: 45 inches wg.
 - 2) Surge: 10 psig.
 - c. Temperature Limits: Minus 30 to 180 deg F.
 - d. Operating Range: Approximately 2 times set point.
 - e. Repeatability: Within 3 percent.
 - f. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 AIR-PRESSURE TRANSMITTERS

A. Air Pressure Differential Transmitter:

1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy: Within 0.25 percent of the span at reference temperature of 70 deg F.
 - c. Hysteresis: Within 0.02 percent of the span.
 - d. Repeatability: Within 0.05 percent of the calibrated span.
 - e. Stability: Within 0.25 percent of span per year.
 - f. Overpressure: 15 psig.
 - g. Temperature Limits: Minus 20 to 160 deg F.
 - h. Compensate Temperature Limits: 35 to 135 deg F.
 - i. Thermal Effects: 0.015 percent of full scale per degree F.
 - j. Warm-up Time: Within 5 seconds.
 - k. Response Time: 5 ms.
 - l. Shock and vibration shall not harm the transmitter.
2. Output Signals:

- a. Analog Current Signal:
 - 1) Two-wire, 4- to 20-mA dc current source.
 - 2) Signal capable of operating into 1000-ohm load.
 - b. Analog Voltage Signal:
 - 1) Three wire, zero to 5 V.
 - 2) Minimum Load Resistance: 1000 ohms.
 3. Operator Interface:
 - a. Zero and span adjustments within 10 percent of full span.
 - b. Potentiometer adjustments located on face of transmitter.
 4. Construction:
 - a. Type 300 stainless-steel enclosure.
 - b. Swivel fittings for connection to copper tubing or barbed fittings for connection to polyethylene tubing. Fittings on front of instrument enclosure.
 - c. Screw terminal block for wire connections.
 - d. Vertical plane mounting.
 - e. NEMA 250, Type 2.
 - f. Mounting Bracket: Appropriate for installation.
 - g. Reverse wiring protected.
 - h. Calibrate to NIST-traceable standards and provide each transmitter with a certificate of calibration.
- B. Air-Pressure Differential Indicating Transmitter:
1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Accuracy Including Hysteresis and Repeatability: Within 1 percent of full scale at 77 deg F.
 - c. Stability: Within 1 percent of full scale per year.
 - d. Overpressure: 10 psig.
 - e. Temperature Limits: 20 to 120 deg F.
 - f. Thermal Effects: 0.055 percent of full scale per degree F.
 2. Display: Four-digit digital display with minimum 0.4-inch-high numeric characters.
 3. Operator Interface:
 - a. Zero and span adjustments.
 - b. Selectable engineering units.
 4. Analog Output Current Signal:
 - a. Two-wire, 4- to 20-mA dc current source.

- b. Signal capable of operating into a 1200-ohm load.
- 5. Construction:
 - a. Plastic casing with clear plastic cover.
 - b. Integral fittings for plastic tubing connections on side of instrument case for high- and low-pressure connections.
 - c. Terminal block for wire connections.
 - d. Vertical plane mounting.
 - e. NEMA 250, Type 1.
 - f. Nominal 4-inch diameter face.
 - g. Mounting Bracket: Appropriate for installation.

2.4 LIQUID-PRESSURE SWITCHES

A. Liquid Gage Pressure Switch, Diaphragm Operated, Low Pressure:

- 1. Description:
 - a. Diaphragm operated to actuate an SPDT snap switch.
 - b. Electrical Connections: Screw terminal.
 - c. Enclosure Conduit Connection: Knock out or threaded connection.
 - d. User Interface: External screw with visual set-point adjustment.
 - e. Process Connection: Threaded, NPS 1/4.
 - f. Enclosure:
 - 1) Dry Indoor Installations: NEMA 250, Type 1.
 - 2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - 3) Hazardous Environments: Explosion proof.
- 2. Operating Data:
 - a. Electrical Rating: 15 A at 120-V ac.
 - b. Pressure Limits:
 - 1) Range 1 to 30 psig: 60 psig.
 - 2) Range 10 to 125 psig: 160 psig.
 - c. Temperature Limits: Minus 30 to 150 deg F.
 - d. Operating Range: 1 to 30 psig.
 - e. Deadband: Fixed.
- 3. Pressure Chamber Material: Stainless steel.
- 4. Diaphragm Material: Nylon or PTFE.

B. Liquid-Pressure Differential Switch with Set-Point Indicator:

- 1. Description:

- a. Brass or Type 316 stainless-steel double opposing bellows operate to actuate a SPDT snap switch.
- b. Electrical Connections: Screw terminal.
- c. Enclosure Conduit Connection: Knock out or threaded connection.
- d. User Interface: Thumbscrew set-point adjustment with enclosed set-point indicator and scale.
- e. High and Low Process Connections: Threaded, NPS 1/8.
- f. Enclosure:
 - 1) Dry Indoor Installations: NEMA 250, Type 1.
 - 2) Outdoor and Wet Indoor Installations: NEMA 250, Type 4.
 - 3) Hazardous Environments: Explosion proof.
- g. Operating Data:
 - 1) Electrical Rating: 15 A at 120- to 240-V ac.
 - 2) Pressure Limits: At least 5 times full-scale range, but not less than system design pressure rating.
 - 3) Temperature Limits: Minus 10 to 180 deg F.
 - 4) Operating Range: Approximately 2 times set point.
 - 5) Deadband: Adjustable or fixed as required by application.

2.5 LIQUID-PRESSURE TRANSMITTERS

A. Liquid-Pressure Differential Transmitter:

- 1. Performance:
 - a. Range: Approximately 2 times set point.
 - b. Span: Adjustable plus or minus one milliamp, noninteractive.
 - c. Accuracy: Within 0.25 percent of full scale.
 - d. Pressure: Maximum operating pressure 2.5 times range.
 - e. Temperature Limits: Zero to 175 deg F.
 - f. Compensate Temperature Limits: 30 to 150 deg F.
 - g. Thermal Effects: 0.02 percent of full scale per degree F.
 - h. Response Time: 30 to 50 ms.
 - i. Shock and vibration shall not harm the transmitter.
- 2. Analog Output Current Signal:
 - a. Two-wire, 4- to 20-mA dc current source.
 - b. Signal capable of operating into 1000-ohm load.
- 3. Operator Interface:
 - a. Zero and span adjustments located behind cover.
 - b. Bleed screws on side of body, two screws on low-pressure side, and one screw on high-pressure side, for air in line and pressure cavity.

4. Construction:
 - a. Aluminum and stainless-steel enclosure with removable cover.
 - b. Wetted parts of transmitter constructed of 17-4 PH or 300 Series stainless steel.
 - c. Threaded, NPS 1/4 process connections on side of instrument enclosure.
 - d. Knock out for 1/2-inch nominal conduit connection on side of instrument enclosure.
 - e. Screw terminal block for wire connections.
 - f. NEMA 250, Type 4X.
 - g. Mounting Bracket: Appropriate for installation.
5. Three-valve manifold. Construct manifold of brass, bronze, or stainless steel. Manifold shall have threaded, NPS 1/4 process connections.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement, sway, or a break in attachment when subjected to a force.
- C. Provide ceiling, floor, roof, wall openings, and sleeves required by installation. Before proceeding with drilling, punching, or cutting, check location first for concealed products that could potentially be damaged. Patch, flash, grout, seal, and refinish openings to match adjacent condition.
- D. Fastening Hardware:
 1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- F. Corrosive Environments:
 1. Use products that are suitable for environment to which they are subjected.
 2. If possible, avoid or limit use of materials in corrosive environments.
 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.

4. Where instruments are located in a corrosive environment and are not corrosive resistant from the manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.2 ELECTRICAL POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 PRESSURE INSTRUMENT INSTALLATION

- A. Mounting Location:
 1. Rough-in: Outline instrument-mounting locations before setting instruments and routing, cable, wiring, tubing, and conduit to final location.
 2. Install switches and transmitters for air and liquid pressure associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid and steam pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install air-pressure switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 5. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
 6. Install instruments (except pressure gages) in steam, liquid, and liquid-sealed piped services below their process connection point. Slope tubing down to instrument with a slope of 2 percent.
 7. Install instruments in dry gas and noncondensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of 2 percent.
- B. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- C. Duct Pressure Sensors:

1. Install sensors using manufacturer's recommended upstream and downstream distances.
2. Unless indicated on Drawings, locate sensors approximately 75 percent of distance of longest hydraulic run. Location of sensors shall be submitted and approved before installation.
3. Install mounting hardware and gaskets to make sensor installation airtight.
4. Route tubing from the sensor to transmitter.
5. Use compression fittings at terminations.
6. Install sensor in accordance with manufacturer's instructions.
7. Support sensor to withstand maximum air velocity, turbulence, and vibration encountered to prevent instrument failure.

D. Outdoor Pressure Sensors:

1. Install roof-mounted sensor in least-noticeable location and as far away from exterior walls as possible.
2. Locate wall-mounted sensor in an inconspicuous location.
3. Submit sensor location for approval before installation.
4. Verify signal from sensor is stable and consistent to all connected transmitters. Modify installation to achieve proper signal.
5. Route outdoor signal pipe full size of sensor connection to transmitters. Install branch connection of size required to match to transmitter.
6. Install sensor signal pipe with dirt leg and drain valve below roof penetration.
7. Insulate signal pipe with flexible elastomeric insulation as required to prevent condensation.
8. Connect roof-mounted signal pipe exposed to outdoors to building grounding system.

E. Air-Pressure Differential Switches:

1. Install air-pressure sensor in system for each switch connection. Install sensor in an accessible location for inspection and replacement.
2. A single sensor may be used to share a common signal to multiple pressure instruments.
3. Install access door in duct and equipment to access sensors that cannot be inspected and replaced from outside.
4. Route NPS 3/8 tubing from sensor to switch connection.
5. Do not mount switches on rotating equipment.
6. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
7. Install switches in an easily accessible location serviceable from floor.
8. Install switches adjacent to system control panel if within 50 feet; otherwise, locate switch in vicinity of system connection.

F. Liquid-Pressure Differential Switches:

1. Where process connections are located in mechanical equipment room, install switch in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate switch near system control panel.

3. Where multiple switches serving same system are installed in same room, install switches by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 1/2. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to switch.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each switch connection.
8. Do not mount switches on rotating equipment.
9. Install switches in a location free from vibration, heat, moisture, or adverse effects, which could damage the switch and hinder accurate operation.
10. Install switches in an easily accessible location serviceable from floor.

G. Liquid-Pressure Transmitters:

1. Where process connections are installed in mechanical equipment room, install transmitter in convenient and accessible location near system control panel.
2. Where process connections are installed outside mechanical rooms, route processing tubing to mechanical room housing system control panel and locate transmitter near system control panel.
3. Where multiple transmitters serving same system are installed in same room, install transmitters by system to provide service personnel a single and convenient location for inspection and service.
4. System process tubing connection shall be full size of switch connection, but not less than NPS 1/2. Install stainless-steel bushing if required to mate switch to system connection.
5. Connect process tubing from point of system connection and extend to transmitter.
6. Install isolation valves in process tubing as close to system connection as practical.
7. Install dirt leg and drain valve at each transmitter connection.
8. Do not mount transmitters on equipment.
9. Install in a location free from vibration, heat, moisture, or adverse effects, which could damage and hinder accurate operation.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

3.5 CHECKOUT PROCEDURES

- A. Check out installed products before continuity tests, leak tests, and calibration.
- B. Check instruments for proper location and accessibility.

- C. Check instruments for proper installation with respect to direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices. Refer to Division 01 Section 017900 "Demonstration and Training."

END OF SECTION 230923.23

SECTION 230923.27 - TEMPERATURE INSTRUMENTS

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. Air temperature sensors.
 - 2. Air temperature switches.
 - 3. Air temperature RTD transmitters.
 - 4. Liquid temperature sensors.
 - 5. High-end, commercial-grade, liquid and steam temperature sensors.
 - 6. Liquid temperature switches.
 - 7. High-end, commercial-grade, liquid and steam temperature transmitters.

- B. Related Requirements:

- 1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings:

- 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of product assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Include number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Environmental Conditions:

1. Instruments shall operate without performance degradation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified and encountered for installed location.
 - a. If instrument alone cannot meet requirement, install instrument in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, filtered, and ventilated as required by instrument and application.
2. Instruments and accessories shall be protected with enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Instruments not available with integral enclosures complying with requirements indicated shall be housed in protective secondary enclosures. Instrument's installed location shall dictate following NEMA 250 enclosure requirements. Enclosure types per Division 23 sections for DDC Control and Instrumentation.

2.2 AIR TEMPERATURE SENSORS

A. Platinum RTDs: Common Requirements:

1. 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
 - a. Range: Minus 50 to 275 deg F.
 - b. Interchangeable Accuracy: At 32 deg F within 0.5 deg F.
 - c. Repeatability: Within 0.5 deg F.
 - d. Self-Heating: Negligible.
4. Transmitter Requirements:
 - a. Transmitter required for each 100-ohm RTD.
 - b. Transmitter optional for 1000-ohm RTD, contingent on compliance with end-to-end control accuracy.

B. Platinum RTD, Single-Point Air Temperature Duct Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.

4. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
5. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
6. Gasket for attachment to duct or equipment to seal penetration airtight.
7. Conduit Connection: 1/2-inch

C. Platinum RTD, Air Temperature Averaging Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Multiple sensors to provide average temperature across entire length of sensor.
4. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
5. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
6. Length: As required by application to cover entire cross section of air tunnel.
7. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
8. Gasket for attachment to duct or equipment to seal penetration airtight.
9. Conduit Connection: 1/2-inch

D. Platinum RTD Outdoor Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 275 deg F
3. Probe: Single-point sensor with a stainless-steel sheath.
4. Solar Shield: Stainless steel.
5. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
6. Conduit Connection: 1/2-inch trade size.

E. Platinum RTD Space Air Temperature Sensors:

1. 100 or 1000 ohms.
2. Temperature Range: Minus 50 to 212 deg F
3. Sensor assembly shall include a temperature sensing element mounted under a flush, brushed-aluminum cover.
4. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
5. Concealed wiring connection.

F. Thermal Resistors (Thermistors): Common Requirements:

1. 10,000 ohms at 25 deg C and a temperature coefficient of 23.5 ohms/ohm/deg C.
2. Two-wire, PTFE-insulated, 22-gage stranded copper leads.
3. Performance Characteristics:
 - a. Range: Minus 50 to 275 deg F.
 - b. Interchangeable Accuracy: At 77 deg F within 0.5 deg F.
 - c. Repeatability: Within 0.5 deg F.

- d. Drift: Within 0.5 deg F over 10 years.
 - e. Self-Heating: Negligible.
- 4. Transmitter optional, contingent on compliance with end-to-end control accuracy.
- G. Thermistor, Single-Point Duct Air Temperature Sensors:
 - 1. Temperature Range: Minus 50 to 275 deg F
 - 2. Probe: Single-point sensor with a stainless-steel sheath.
 - 3. Length: As required by application to achieve tip at midpoint of air tunnel, up to 18 inches.
 - 4. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
 - 5. Gasket for attachment to duct or equipment to seal penetration airtight.
 - 6. Conduit Connection: 1/2- inch trade size.
- H. Thermistor Averaging Air Temperature Sensors:
 - 1. Temperature Range: Minus 50 to 275 deg F
 - 2. Multiple sensors to provide average temperature across entire length of sensor.
 - 3. Rigid probe of aluminum, brass, copper, or stainless-steel sheath.
 - 4. Flexible probe of aluminum, brass, copper, or stainless-steel sheath and formable to a 4-inch radius.
 - 5. Length: As required by application to cover entire cross section of air tunnel.
 - 6. Enclosure: Junction box with removable cover; NEMA 250, Type 1 for indoor applications and Type 4 for outdoor applications.
 - 7. Gasket for attachment to duct or equipment to seal penetration airtight.
 - 8. Conduit Connection: 1/2-inch trade size.
- I. Thermistor Outdoor Air Temperature Sensors:
 - 1. Temperature Range: Minus 50 to 275 deg F
 - 2. Probe: Single-point sensor with a stainless-steel sheath.
 - 3. Solar Shield: Stainless steel.
 - 4. Enclosure: NEMA 250, Type 4 or 4X junction box or combination conduit and outlet box with removable cover and gasket.
 - 5. Conduit Connection: 1/2-inch trade size.
- J. Thermistor Space Air Temperature Sensors:
 - 1. Temperature Range: Minus 50 to 212 deg F
 - 2. Sensor assembly shall include a temperature sensing element mounted under a flush, brushed-aluminum cover.
 - 3. Provide a mounting plate that is compatible with the surface shape that it is mounted to and electrical box used.
 - 4. Concealed wiring connection.
- K. Space Air Temperature Sensors for Use with DDC Controllers Controlling Terminal Units:
 - 1. 100- or 1000-ohm platinum RTD or thermistor.

2. Thermistor:
 - a. Pre-aged, burned in, and coated with glass; inserted in a metal sleeve; and entire unit encased in epoxy.
 - b. Thermistor drift shall be less than plus or minus 0.5 deg F over 10 years.
3. Temperature Transmitter Requirements:
 - a. Mating transmitter required with each 100-ohm RTD.
 - b. Mating transmitters optional for 1000-ohm RTD and thermistor, contingent on compliance with end-to-end control accuracy.
4. Provide digital display of sensed temperature.
5. Provide sensor with local control.
 - a. Local override to turn HVAC on.
 - b. Local adjustment of temperature set point.
 - c. Both features shall be capable of manual override through control system operator.

2.3 AIR TEMPERATURE SWITCHES

A. Thermostat and Switch for Low Temperature Control in Duct Applications:

1. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Performance:
 - a. Operating Temperature Range: 15 to 55 deg F.
 - b. Temperature Differential: 5 deg F, non-adjustable and additive.
 - c. Enclosure Ambient Temperature: Minus 20 to 140 deg F.
 - d. Sensing Element Maximum Temperature: 250 deg F.
 - e. Voltage: 120-V ac.
 - f. Current: 16 FLA.
 - g. Switch Type: Two SPDT snap switches operate on coldest 12-inch section along element length.
3. Construction:
 - a. Vapor-Filled Sensing Element: Nominal 20 feetlong.
 - b. Dual Temperature Scale: Fahrenheit and Celsius visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal, NEMA 250, Type 1.
 - e. Electrical Connections: Screw terminals.

f. Conduit Connection: 1/2-inch trade size.

B. Thermostat and Switch for High Temperature Control in Duct Applications:

1. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
2. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Performance:
 - a. Temperature Range: 100 to 160 deg F.
 - b. Temperature Differential: 5 deg F.
 - c. Ambient Temperature: Zero to 260 deg F.
 - d. Voltage: 120-V ac.
 - e. Current: 16 FLA.
 - f. Switch Type: SPDT snap switch.
4. Construction:
 - a. Sensing Element: Helical bimetal.
 - b. Enclosure: Metal, NEMA 250, Type 1.
 - c. Electrical Connections: Screw terminals.
 - d. Conduit Connection: 1/2-inch trade size.

2.4 AIR TEMPERATURE RTD TRANSMITTERS

- A. Source Limitations: Obtain temperature-measuring sensors and transmitters and airflow from single manufacturer.
- B. House electronics in NEMA 250 enclosure as indicated in Division 230923 sections for DDC Control and Instrumentation.
- C. Conduit Connection: 1/2-inch
- D. Functional Characteristics:
 1. Input:
 - a. 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.
 - b. 1000-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two-wire sensors.

2. Span (Adjustable):
 - a. Space: 40 to 90 deg F.
 - b. Supply Air Cooling and Heating: 40 to 120 deg F.
 - c. Supply Air Cooling Only: 40 to 90 deg F.
 - d. Supply Air Heating Only: 40 to 120 deg F.
 - e. Exhaust Air: 50 to 100 deg F.
 - f. Return Air: 50 to 100 deg F.
 - g. Mixed Air: Minus 40 to 140 deg F.
 - h. Outdoor: Minus 40 to 140 deg F.
3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together.

E. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

2.5 LIQUID TEMPERATURE SENSORS, COMMERCIAL GRADE

A. RTD:

1. Description:
 - a. Platinum with a value of 100 or 1000 ohms at zero deg C and a temperature coefficient of 0.00385 ohm/ohm/deg C.
 - b. Encase RTD in a stainless-steel sheath with a 0.25-inch OD.
 - c. Sensor Length: 4, 6, or 8 inches as required by application.
 - d. Process Connection: Threaded, NPS 1/2
 - e. Two-stranded copper lead wires.
 - f. Powder-coated steel enclosure, NEMA 250, Type 4.
 - g. Conduit Connection: 1/2-inch
 - h. Performance Characteristics:
 - 1) Range: Minus 40 to 210 deg F.
 - 2) Interchangeable Accuracy: Within 0.54 deg F at 32 deg F.

B. Thermowells:

1. Stem: Straight or stepped shank formed from solid bar stock.
2. Material: Brass.
3. Process Connection: Threaded, NPS 3/4.
4. Sensor Connection: Threaded, NPS 1/2.
5. Bore: Sized to accommodate sensor with tight tolerance between sensor and well.

6. Furnish thermowells installed in insulated pipes and equipment with an extended neck.
7. Length: 4, 6, or 8 inches as required by application.
8. Thermowells furnished with heat-transfer compound to eliminate air gap between wall of sensor and thermowell and to reduce time constant.

2.6 LIQUID TEMPERATURE SWITCHES

A. Thermostat and Switch for Temperature Control in Pipe Applications:

1. Description:
 - a. Two-position control.
 - b. Field-adjustable set point.
 - c. Manual reset.
 - d. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Performance:
 - a. Operating Temperature Range: 65 to 200 deg F.
 - b. Temperature Differential Deadband: 5 to 30 deg F, adjustable.
 - c. Enclosure Ambient Temperature: 150 deg F.
 - d. Sensing Element Pressure Rating: 200 psig.
 - e. Voltage: 120-V ac.
 - f. Current: 8 FLA.
 - g. Switch Type: SPDT snap switch.
3. Construction:
 - a. Vapor-Filled Immersion Element: Copper, nominal 3 inches long.
 - b. Temperature Scale: Fahrenheit, visible on face.
 - c. Set-Point Adjustment: Screw.
 - d. Enclosure: Painted metal, NEMA 250, Type 1.
 - e. Electrical Connections: Screw terminals.
 - f. Conduit Connection: 3/4-inch.

2.7 LIQUID TEMPERATURE TRANSMITTERS, COMMERCIAL GRADE

- A. House electronics in NEMA 250, Type 4X enclosure.
- B. Enclosure Connection: 1/2-inch trade size.
- C. Functional Characteristics:
 1. Input: 100-ohm platinum RTD temperature coefficient of 0.00385 ohm/ohm/deg C, two- or three-wire sensors.
 2. Default Span (Adjustable):

- a. Chilled Water: Zero to 100 deg F.
- b. Heating Hot Water: 32 to 212 deg F.
- c. Heat Recovery: Zero to 120 deg F.
3. Output: 4- to 20-mA dc, linear with temperature; RFI insensitive; minimum drive load of 600 ohms at 24-V dc.
4. Zero and span field adjustments, plus or minus 5 percent of span. Minimum span of 50 deg F.
5. Match sensor with temperature transmitter and factory calibrate together. Each matched sensor and transmitter set shall include factory calibration data traceable to NIST.

D. Performance Characteristics:

1. Calibration Accuracy: Within 0.1 percent of the span.
2. Stability: Within 0.2 percent of the span for at least 6 months.
3. Combined Accuracy: Within 0.5 percent.

PART 3 - EXECUTION

3.1 TEMPERATURE INSTRUMENT APPLICATIONS

A. Air Temperature Sensors:

1. Duct: 100-ohm platinum RTD 1000-ohm platinum RTD.
2. Outdoor: 100-ohm platinum RTD 1000-ohm platinum RTD.
3. Space: 100-ohm platinum RTD 1000-ohm platinum RTD.

B. Air Temperature Transmitters:

1. Duct: Air temperature RTD transmitter.
2. Outdoor: Air temperature RTD transmitter.
3. Space: Air temperature RTD transmitter.

C. Liquid and Temperature Transmitters:

1. Heating Hot Water System: Liquid temperature transmitter, commercial grade.
2. Chilled Water System: Liquid temperature transmitter, commercial grade.

3.2 INSTALLATION, GENERAL

- A. Install products level, plumb, parallel, and perpendicular with building construction.
- B. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to a force.
- C. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by excessive force or by oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- D. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- E. Corrosive Environments:
1. Use products that are suitable for environment to which they are subjected.
 2. If possible, avoid or limit use of materials in corrosive environments.
 3. When conduit is in contact with a corrosive environment, use Type 316 stainless-steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
 4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."

3.4 TEMPERATURE INSTRUMENT INSTALLATIONS

- A. Mounting Location:
 1. Roughing In:
 - a. Outline instrument mounting locations before setting instruments and routing cable, wiring, tubing, and conduit to final location.
 - b. Provide independent inspection to confirm that proposed mounting locations comply with requirements indicated and approved submittals.
 - 1) Indicate dimensioned locations with mounting height for all surface-mounted products on Shop Drawings.
 - 2) Do not begin installation without submittal approval of mounting location.

- c. Complete installation rough-in only after confirmation by independent inspection is complete and approval of location is documented for review by Owner and Architect on request.
 2. Install switches and transmitters for air and liquid temperature associated with individual air-handling units and associated connected ductwork and piping near air-handling units co-located in air-handling unit system control panel to provide service personnel a single and convenient location for inspection and service.
 3. Install liquid temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 4. Install air temperature switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
 5. Mount switches and transmitters on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
- B. Special Mounting Requirements:
1. Protect products installed outdoors from solar radiation, building and wind effect with stand-offs and shields constructed of Type 316 stainless.
 2. Temperature instruments having performance impacted by temperature of mounting substrate shall be isolated with an insulating barrier located between instrument and substrate to eliminate effect. Where instruments requiring insulation are located in finished space, conceal insulating barrier in a cover matching the instrument cover.
- C. Mounting Height:
1. Mount temperature instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.
 2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code or state and Federal accessibility requirements within a range of 42 to 72 inches above the adjacent floor, grade, or service catwalk or platform.
 - a. Make every effort to mount at 60 inches.
- D. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.
- E. Space Temperature Sensor Installation:
1. Conceal assembly in an electrical box of sufficient size to house sensor and transmitter, if provided.
 2. Install electrical box with a faceplate to match sensor cover if sensor cover does not completely cover electrical box.
 3. In finished areas, recess electrical box within wall.

4. In unfinished areas, electrical box may be surface mounted if electrical light switches are surface mounted. Use a cast-aluminum electric box for surface-mounted installations.
5. Align electrical box with other electrical devices such as visual alarms and light switches located in the vicinity to provide a neat and well-thought-out arrangement. Where possible, align in both horizontal and vertical axis.

F. Outdoor Air Temperature Sensor Installation:

1. Mount sensor in a discrete location facing north.
2. Protect installed sensor from solar radiation and other influences that could impact performance.
3. If required to have a transmitter, mount transmitter remote from sensor in an accessible and serviceable location indoors.

G. Single-Point Duct Temperature Sensor Installation:

1. Install single-point-type, duct-mounted, supply- and return-air temperature sensors. Install sensors in ducts with sensitive portion of the element installed in center of duct cross section and located to sense near average temperature. Do not exceed 24 inches in sensor length.
2. Install return-air sensor in location that senses return-air temperature without influence from outdoor or mixed air.
3. Rigidly support sensor to duct and seal penetration airtight.
4. If required to have transmitter, mount transmitter remote from sensor at accessible and serviceable location.

H. Averaging Duct Temperature Sensor Installation:

1. Install averaging-type air temperature sensor for temperature sensors located within air-handling units, similar equipment, and large ducts with air tunnel cross-sectional area of 20 sq. ft. and larger.
2. Install sensor length to maintain coverage over entire cross-sectional area. Install multiple sensors where required to maintain the minimum coverage.
3. Fasten and support sensor with manufacturer-furnished clips to keep sensor taut throughout entire length.
4. If required to have transmitter, mount transmitter in an accessible and serviceable location.

I. Low-Limit Air Temperature Switch Installation:

1. Install multiple low-limit switches to maintain coverage over entire cross-sectional area of air tunnel.
2. Fasten and support sensing element with manufacturer-furnished clips to keep element taut throughout entire length.
3. Mount switches outside of airstream at a location and mounting height to provide easy access for switch set-point adjustment and manual reset.
4. Install on entering side of cooling coil unless otherwise indicated on Drawings.

J. Liquid Temperature Sensor Installation:

1. Assembly shall include sensor, thermowell and connection head.
2. For pipe NPS 4 and larger, install sensor and thermowell length to extend into pipe between 50 to 75 percent of pipe cross section.
3. For pipe smaller than NPS 4:
 - a. Install reducers to increase pipe size to NPS 4 at point of thermowell installation.
 - b. For pipe sizes NPS 2-1/2 and NPS 3, thermowell and sensor may be installed at pipe elbow or tee to achieve manufacturer-recommended immersion depth in lieu of increasing pipe size.
 - c. Minimum insertion depth shall be 2-1/2 inches.
4. Install matching thermowell.
5. Fill thermowell with heat-transfer fluid before inserting sensor.
6. Tip of spring-loaded sensors shall contact inside of thermowell.
7. For insulated piping, install thermowells with extension neck to extend beyond face of insulation.
8. Install thermowell in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. If top dead center location is not possible due to field constraints, install thermowell at location along top half of pipe.
9. For applications with transmitters, mount transmitter remote from sensor in an accessible and serviceable location from floor service platform or catwalk.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification.

3.6 CLEANING

- A. Remove grease, mastic, adhesives, dust, dirt, stains, fingerprints, labels, and other foreign materials from exposed interior and exterior surfaces.
- B. Wash and shine glazing.
- C. Polish glossy surfaces to a clean shine.

3.7 CHECK-OUT PROCEDURES

- A. Check installed products before continuity tests, leak tests, and calibration.
- B. Check temperature instruments for proper location and accessibility.
- C. Verify sensing element type and proper material.

- D. Verify location and length.
- E. Verify that wiring is correct and secure.

3.8 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform according to manufacturer's written instruction.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Prepare test and inspection reports.

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within 24 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 4 visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices. Refer to Division 01 Section 017900 "Demonstration and Training."

END OF SECTION 230923.27

SECTION 231123 - FACILITY NATURAL-GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Manual gas shutoff valves.
5. Motorized gas valves.
6. Earthquake valves.
7. Pressure regulators.
8. Dielectric fittings.
9. Gas Service Fittings

1.3 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 1. Piping specialties.
 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 3. Pressure regulators. Indicate pressure ratings and capacities.
 4. Dielectric fittings.

- B. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
 - 1. Shop Drawing Scale: 1/4 inch per foot.
 - 2. Detail mounting, supports, and valve arrangements for pressure regulator assembly.
- C. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of seismic restraints.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Site Survey: Plans, drawn to scale, on which natural-gas piping is shown and coordinated with other services and utilities.
- C. Qualification Data: For qualified professional engineer.
- D. Welding certificates.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For motorized gas valves and pressure regulators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.8 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.

1.9 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. 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 Architect and Owner 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 Owner's written permission.

1.10 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Section 083113 "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- A. Natural-Gas System Pressure within Buildings: More than 0.5 psig but not more than 2 psig.

- B. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

2.2 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. Lapped Face: Not permitted underground.
 - 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 aboveground and stainless steel underground.
 5. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
 6. Mechanical Couplings:
 - a. Steel flanges and tube with epoxy finish.
 - b. Buna-nitrile seals.
 - c. Steel bolts, washers and nuts.
 - d. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
 - e. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

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

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

C. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 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.

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

2.4 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.
- B. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 MANUAL GAS SHUTOFF VALVES

- A. See "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.

6. 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. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- D. Two-Piece, Full-Port, Bronze Ball Valves with Stainless Steel Trim: MSS SP-110.
1. Body: Bronze, complying with ASTM B 584.
 2. Ball: Chrome-plated bronze.
 3. Stem: Bronze; blowout proof.
 4. Seats: Reinforced TFE; blowout proof.
 5. Springs and Valve Trim: Stainless Steel.
 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 8. CWP Rating: 600 psig.
 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.
 11. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- E. Bronze Plug Valves: MSS SP-78.
1. Body: Bronze, complying with ASTM B 584.
 2. Plug: Bronze.
 3. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 4. Operator: Square head or lug type with tamperproof feature where indicated.
 5. Pressure Class: 125 psig.
 6. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 7. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- F. Valve Boxes:
1. Cast-iron, two-section box.
 2. Top section with cover with "GAS" lettering.
 3. Bottom section with base to fit over valve and barrel a minimum of 5 inches in diameter.
 4. Adjustable cast-iron extensions of length required for depth of bury.
 5. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

2.6 MOTORIZED GAS VALVES

A. Automatic Gas Valves: Comply with ANSI Z21.21.

1. Body: Brass or aluminum.
2. Seats and Disc: Nitrile rubber.
3. Springs and Valve Trim: Stainless steel.
4. Normally closed.
5. Visual position indicator.
6. Mechanical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

1. Pilot operated.
2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
6. NEMA ICS 6, Type 4, coil enclosure.
7. Normally closed.
8. Visual position indicator.

2.7 EARTHQUAKE VALVES

A. Earthquake Valves, Maximum Operating Pressure of 60 psig: Comply with ASCE 25.

1. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
2. Maximum Operating Pressure: 7 psig.
3. Cast-aluminum body with stainless-steel internal parts.
4. Nitrile-rubber, reset-stem o-ring seal.
5. Valve position, open or closed, indicator.
6. Composition valve seat with clapper held by spring or magnet locking mechanism.
7. Level indicator.
8. End Connections: Threaded for valves NPS 2 and smaller; flanged for valves NPS 2-1/2 and larger.

2.8 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. Service Pressure Regulators: Comply with ANSI Z21.80.

1. Body and Diaphragm Case: Cast iron or die-cast aluminum.
2. Springs: Zinc-plated steel; interchangeable.
3. Diaphragm Plate: Zinc-plated steel.
4. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
5. Orifice: Aluminum; interchangeable.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
8. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
9. Overpressure Protection Device: Factory mounted on pressure regulator.
10. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
11. Maximum Inlet Pressure: 100 psig.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Meter Company.
 - b. Invensys.
 - c. Maxitrol Company.
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.

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

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Eaton.
 - b. Harper Wyman Co.
 - c. Maxitrol Company.

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.

2.9 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. WATTS.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. WATTS.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

2.10 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.

2.11 GAS SERVICE FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Chicago Faucets; Geberit Company.
- B. Service Fittings: Provide units that comply with SEFA 7, "Recommended Practices for Fixtures." Provide fittings complete with washers, locknuts, nipples, and other installation accessories. Include wall and deck flanges, escutcheons, handle extension rods, and similar items.
 - 1. Provide units that comply with "Vandal-Resistant Faucets and Fixtures" recommendations in SEFA 7.
- C. Materials: Fabricated from cast or forged red brass unless otherwise indicated.
- D. Finish: Chromium plated.
- E. Ball Valves: Chrome-plated ball and PTFE seals. Handle requires no more than 5 lbf to operate. Provide units designed for working pressure up to 75 psig, with serrated outlets.
 - 1. Locking Safety Handles: Where ball valves are indicated for fuel-gas use, provide handles that must be pushed in or pulled up before being turned on.
- F. Hand of Fittings: Furnish right-hand fittings unless fitting designation is followed by "L."
- G. Handles: Provide three- or four-arm, forged-brass handles for valves unless otherwise indicated.
 - 1. Provide lever-type handles for ball valves unless otherwise indicated. Lever handle aligns with outlet when valve is closed and is perpendicular to outlet when valve is fully open.
- H. Service-Outlet Identification: Provide color-coded plastic discs with embossed identification, secured to each service-fitting handle to be tamper resistant. Comply with SEFA 7 for colors and embossed identification.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with 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. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- C. Install pressure gage downstream from each service regulator. Pressure gages are specified in Section 230519 "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 natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Verify final equipment locations for roughing-in.
- L. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- M. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- N. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- O. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- P. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
 - 2. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 - 3. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 - 4. Prohibited Locations:
 - a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural-gas piping in solid walls or partitions.

- Q. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- R. Connect branch piping from top or side of horizontal piping.
- S. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- T. Do not use natural-gas piping as grounding electrode.
- U. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- V. Install pressure gage upstream and downstream from each line regulator. Pressure gages are specified in Section 230519 "Meters and Gages for HVAC Piping."
- W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.5 INSTALLATION OF SERVICE FITTINGS

- A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.
- B. Install fittings according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

3.6 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- C. Install earthquake valves aboveground outside buildings according to listing.

3.7 PIPING JOINT CONSTRUCTION

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

3.8 HANGER AND SUPPORT INSTALLATION

- A. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Comply with requirements for pipe hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- C. 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.

3.9 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.10 LABELING AND IDENTIFYING

- A. Comply with requirements in Section 230553 "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.

3.11 PAINTING

- A. Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for painting interior and exterior natural-gas piping.
- B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel (semigloss).
 - d. Color: Insert color.
- C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
 - 1. Latex Over Alkyd Primer System: MPI INT 5.1Q.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
- D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.12 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.

3.13 DEMONSTRATION

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

3.14 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

B. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.
3. Drawn-temper copper tube with wrought-copper fittings and brazed joints.

C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

D. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
- B. Aboveground, distribution piping shall be the following:
 1. Steel pipe with steel welding fittings and welded joints.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- D. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.17 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 and smaller at service meter shall be the following:
 1. Two-piece, full-port, bronze ball valves with stainless steel trim.
- B. Valves for pipe sizes NPS 2-1/2 and larger at service meter shall be the following:
 1. Two-piece, full-port, bronze ball valves with stainless steel trim.
- C. Valves in branch piping for single appliance shall be the following:
 1. Two-piece, full-port, bronze ball valves with stainless steel trim.

3.18 SERVICE-FITTING SCHEDULE

- A. Laboratory Gas Service Fitting (Turret):
 1. Service: Gas (fuel gas).
 2. Fitting Type: Turret.
 3. Outlets: Two, at 90 degrees.
 4. Outlet Type: Angled.
 5. Valve Type: Ball valve.

END OF SECTION 231123

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes pipe and fitting materials and joining methods for the following:

1. Copper tube and fittings.
2. Steel pipe and fittings.
3. Joining materials.
4. Transition fittings.
5. Dielectric fittings.
6. Bypass chemical feeder.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:

1. Pipe.
2. Fittings.
3. Joining materials.
4. Bypass chemical feeder.

- B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Welding certificates.

C. Field quality-control reports.

1. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 1. Hot-Water Heating Piping: 125 psig at 200 deg F.
 2. Chilled-Water Piping: 125 psig at 200 deg F.
 3. Makeup-Water Piping: 125 psig at 200 deg F.
 4. Condensate-Drain Piping: 150 deg F.
 5. Blowdown-Drain Piping: 200 deg F.
 6. Air-Vent Piping: 200 deg F.
 7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Cast-Copper, Solder-Joint Fittings: ASME B16.18, pressure fittings.
- E. Wrought-Copper, Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
- F. Wrought-Copper Unions: ASME B16.22

- G. Bullhead tee fittings not acceptable.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- C. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- D. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- E. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- F. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.
- G. Bullhead tee fittings not acceptable.

2.4 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless otherwise indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- E. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

- F. Gasket Material: Thickness, material and type suitable for fluid to be handled and working temperatures and pressures.
- G. Grooved couplings/fittings are acceptable for use with hot/chilled water piping NPS 2-1/2 and larger within mechanical/equipment/service yard areas only.

2.5 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 150 psig.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges:
 - 1. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 150 psig.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Insulating Kits:
 - 1. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.
- E. Dielectric Nipples:
 - 1. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F 1545.
 - c. Pressure Rating: 300 psig at 225 deg F.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

2.6 BYPASS CHEMICAL FEEDER

- A. Description: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.
 - 1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, NPS 2-1/2 and smaller, shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
- B. Hot-water heating piping, aboveground, NPS 3 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.
- C. Makeup-water piping installed aboveground shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.
- D. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.
- E. Condensate-Drain Piping: Type M Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- F. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.
- G. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.
- H. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
 - 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.
- 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 with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to the following:
 - 1. Section 230523.12 "Ball Valves for HVAC Piping."
 - 2. Section 230523.13 "Butterfly Valves for HVAC Piping."
 - 3. Section 230523.14 "Check Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve in piping, 2 inch and larger, immediately upstream of each dielectric fitting.
- T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for 2 inch and Smaller: Use dielectric nipples.
- C. Dielectric Fittings for 2-1/2 to 8 inch: Use dielectric flange kits or nipples.
- D. Dielectric Unions: Not Allowed (per BSD Standards)

3.4 HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.
- B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- 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.

6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet.
 2. NPS 1: Maximum span, 7 feet.
 3. NPS 1-1/2: Maximum span, 9 feet.
 4. NPS 2: Maximum span, 10 feet.
 5. NPS 2-1/2: Maximum span, 11 feet.
 6. NPS 3 and Larger: Maximum span, 12 feet.
- 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 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "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.
- G. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
- B. Install bypass chemical feeders in each hydronic system where indicated.
 - 1. Install in upright position with top of funnel not more than 48 inches above the floor.
 - 2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
 - 3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.
- C. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- D. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.8 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232116 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 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. Hydronic specialty valves.
 - 2. Air-control devices.
 - 3. Strainers.
 - 4. Connectors.

- B. Related Requirements:

- 1. Section 230523.12 "Ball Valves for HVAC Piping" for specification and installation requirements for ball valves common to most piping systems.
 - 2. Section 230523.13 "Butterfly Valves for HVAC Piping" for specification and installation requirements for butterfly valves common to most piping systems.
 - 3. Section 230523.14 "Check Valves for HVAC Piping" for specification and installation requirements for check valves common to most piping systems.
 - 4. Section 230923.11 "Control Valves" for automatic control valve and sensor specifications, installation requirements, and locations.

1.3 ACTION SUBMITTALS

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

- 1. Hydronic Specialty Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air-Control devices
 - 3. Strainers
 - 4. Connectors

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Safety Valves and Pressure Vessels: Shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 HYDRONIC SPECIALTY VALVES

- A. Bronze, Calibrated-Orifice, Balancing Valves:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Bell & Gossett; a Xylem brand.
 - b. Flow Design, Inc.
 - c. Griswold Controls.
 - d. Tour & Andersson; available through Victaulic Company.
 - e. Victaulic Company.
 - 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.
- B. 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; a Xylem brand.
 - b. Flow Design, Inc.

- c. Griswold Controls.
 - d. Tour & Andersson; available through Victaulic Company.
 - e. Victaulic Company.
 - 2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 - 3. Ball: Brass or stainless steel.
 - 4. Stem Seals: EPDM O-rings.
 - 5. Disc: Glass and carbon-filled PTFE.
 - 6. Seat: PTFE.
 - 7. End Connections: Flanged or grooved.
 - 8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 - 9. Handle Style: Lever, with memory stop to retain set position.
 - 10. CWP Rating: Minimum 125 psig.
 - 11. Maximum Operating Temperature: 250 deg F.
- C. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Bell & Gossett; a Xylem brand.
 - b. Flow Design, Inc.
 - c. Griswold Controls.
 - d. Tour & Anderson.
 - e. Victaulic Company.
 - 2. Body: Bronze or brass.
 - 3. Disc: Glass and carbon-filled PTFE.
 - 4. Seat: Brass.
 - 5. Stem Seals: EPDM O-rings.
 - 6. Diaphragm: EPT.
 - 7. Low inlet-pressure check valve.
 - 8. Inlet Strainer: Stainless Steel, removable without system shutdown.
 - 9. Valve Seat and Stem: Noncorrosive.
 - 10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.
- D. Diaphragm-Operated Safety Valves: ASME labeled.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Bell & Gossett; a Xylem brand.
 - b. Flow Design, Inc.
 - c. Griswold Controls.
 - d. Tour & Anderson.
 - e. Victaulic Company.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: Stainless Steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

E. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Bell & Gossett; a Xylem brand.
 - b. Flow Design, Inc.
 - c. Griswold Controls.
 - d. Tour & Anderson.
 - e. Victaulic Company.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow within plus or minus 5 percent, regardless of system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.

2.2 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. TACO Comfort Solutions
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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. TACO Comfort Solutions
2. Body: Bronze or cast iron.
3. Internal Parts: Nonferrous.
4. Operator: Noncorrosive metal float.
5. Inlet Connection: NPS 1/2.
6. Discharge Connection: NPS 1/4.
7. CWP Rating: 150 psig.
8. Maximum Operating Temperature: 240 deg F.

C. Bladder-Type Expansion Tanks:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. TACO Comfort Solutions
 - d. Armstrong
2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after tanks are fabricated and supports installed and are 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.

D. Coalescing-Type Air and Dirt Separators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. TACO Comfort Solutions

d. Armstrong

2. Tank: Fabricated steel tank; ASME constructed and stamped for 125-psig working pressure and 270 deg F maximum operating temperature.
3. Coalescing Medium: Stainless steel.
4. Air Vent: Threaded to the top of the separator.
5. Inline Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; Class 150 flanged connections for NPS 2-1/2 (DN 65) and larger.
6. Blowdown Connection: Threaded to the bottom of the separator.
7. Size: Match system flow capacity.

E. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. TACO Comfort Solutions
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig.
4. Maximum Operating Temperature: 250 deg F.

2.3 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 40-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

2.4 CONNECTORS

A. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.
6. Maximum Length: 2 feet (per BSD standards)

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 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. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install coalescing air and dirt separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

- F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Close-coupled, in-line centrifugal pumps.
- B. Related Sections include the following:
 - 1. Section 230513 "Common Motor Requirements for HVAC Equipment" for requirements.
 - 2. Section 232116 "Hydronic Piping Specialties" for specialties not specified in this section.

1.3 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Shop Drawings: For each pump.
 - 1. Show pump layout and connections.
 - 2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps 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. 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 wooden flange covers or with screwed-in plugs.
- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage.
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.7 COORDINATION

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

1.8 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. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 GENERAL PUMP REQUIREMENTS

- A. Pump Units: Factory assembled and tested.

- B. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be non-overloading over full range of pump performance curve.
- C. Motors Indicated to Be Energy Efficient: Minimum efficiency as scheduled on the drawings.

2.2 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Grundfos Pumps Inc.
 - 2. ITT Corporation; Bell & Gossett
 - 3. Aurora Pump; Division of Pentair Pump Group.
 - 4. Armstrong
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet and threaded companion-flange connections.
 - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw.
 - 3. Pump Shaft: Stainless steel.
 - 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
 - 5. Pump Bearings: Permanently lubricated ball bearings.
- D. Motor: Single speed and rigidly mounted to pump casing.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - a. Enclosure: Totally enclosed, fan cooled.
- E. Capacities and Characteristics: As scheduled

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps to provide adequate access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to pump, allow space for service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install suction diffuser and shutoff valve on suction side of pumps.
- F. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

- H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- J. Install ports for hand held pressure gages at permanent pressure gage connections according to Division 23 Section "Meters and Gages for HVAC Piping."

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. 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.

3.5 DEMONSTRATION

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

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- 1. This section includes refrigerant piping used for air-conditioning applications.

1.3 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Air-Conditioning Applications: 300 psig
 - 2. Suction Lines for Heat-Pump Applications: 535 psig.
 - 3. Hot-Gas and Liquid Lines: 535 psig.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve, refrigerant piping, and piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
- B. Shop Drawings:
 - 1. 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.
 - 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.
- C. Operation and maintenance data. For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 PRODUCT STORAGE AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8/A5.8M.
- E. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Working Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.2 REFRIGERANTS

- A. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-Gas, Liquid and Suction lines for Heat-Pump Applications: Copper, ACR Tubing and wrought-copper fittings with brazed joints.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss,

expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on 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 Section 230923 "Direct Digital Control (DDC) System for HVAC" and plans 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 Section 083113 "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 piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- R. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 PIPE JOINT CONSTRUCTION

- A. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."

3.4 HANGERS AND SUPPORTS

- A. Comply with requirements for pipe hangers and supports specified in Section 230529 "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 diameters:
 - 1. NPS 1/2: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 2. NPS 5/8: Maximum span, 60 inches; minimum rod, 1/4 inch.
 - 3. NPS 1: Maximum span, 72 inches; minimum rod, 1/4 inch.
 - 4. NPS 1-1/4: Maximum span, 96 inches; minimum rod, 3/8 inch.
 - 5. NPS 1-1/2: Maximum span, 96 inches; minimum rod, 3/8 inch.
 - 6. NPS 2: Maximum span, 96 inches; minimum rod, 3/8 inch.
 - 7. NPS 2-1/2: Maximum span, 108 inches; minimum rod, 3/8 inch.
 - 8. NPS 3: Maximum span, 10 feet; minimum rod, 3/8 inch.
 - 9. NPS 4: Maximum span, 12 feet; minimum rod, 1/2 inch.

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
1. Comply with ASME B31.5, Chapter VI.
 2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
 3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in "Performance Requirements" Article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gage throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.
- B. Prepare test and inspection reports.

3.6 SYSTEM CHARGING

- A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 4. Charge system with a new filter-dryer core in charging line.

3.7 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.

5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232513 - WATER TREATMENT FOR CLOSED-LOOP HYDRONIC SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes the following water treatment for closed-loop hydronic systems:

- 1. Manual chemical-feed equipment.
- 2. Chemicals.

1.3 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.
- B. RO: Reverse osmosis.
- C. TSS: Total suspended solids are solid materials, including organic and inorganic, that are suspended in the water. These solids may include silt, plankton, and industrial wastes.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for the following products:
 - 1. Bypass feeders.
 - 2. Water meters.
 - 3. Inhibitor injection timers.
 - 4. pH controllers.
 - 5. TSS controllers.
 - 6. Chemical solution tanks.
 - 7. Injection pumps.
 - 8. Chemical test equipment.
 - 9. Chemical material safety data sheets.
- B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to hydronic systems.
 - 1. Include plans, elevations, sections, and attachment details.

2. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For 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.
- B. Water Analysis Provider Qualifications: Verification of experience and capability of HVAC water-treatment service provider.
- C. Field quality-control reports.
- D. Other Informational Submittals:
 1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in "Performance Requirements" Article.
 2. Water Analysis: Illustrate water quality available at Project site.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sensors, injection pumps, and controllers to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. HVAC Water-Treatment Service Provider: Watercare Industrial Services, Washougal, WA.

1.8 MAINTENANCE SERVICE

- A. Scope of Maintenance Service: Provide chemicals and service program to maintain water conditions required above to inhibit corrosion and scale formation for hydronic piping and equipment. Services and chemicals shall be provided for a period of one year from date of Substantial Completion and shall include the following:
 1. Initial water analysis and HVAC water-treatment recommendations.
 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 3. Periodic field service and consultation.
 4. Customer report charts and log sheets.
 5. Laboratory technical analysis.

6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
- B. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
- C. Closed hydronic systems, including hot-water heating and chilled water, shall have the following water qualities:
 1. pH: Maintain a value within 9.0 to 10.5.
 2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
 3. Boron: Maintain a value within 100 to 200 ppm.
 4. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
 5. Soluble Copper: Maintain a maximum value of 0.20 ppm.
 6. TSS: Maintain a maximum value of 10 ppm.
 7. Ammonia: Maintain a maximum value of 20 ppm.
 8. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
 9. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/mL.
 - b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/mL.
 - c. Nitrate Reducers: Maintain a maximum value of 100 organisms/mL.
 - d. Sulfate Reducers: Maintain a maximum value of zero organisms/mL.
 - e. Iron Bacteria: Maintain a maximum value of zero organisms/mL.

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: 5 gal.
 2. Minimum Working Pressure: 125 psig.

2.3 CHEMICALS

- A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment and that can attain water quality specified in "Performance Requirements" Article.

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

- 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 seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- C. Install water testing equipment on wall near water chemical application equipment.
- D. Install interconnecting control wiring for chemical treatment controls and sensors.
- E. Mount sensors and injectors in piping circuits.
- F. Bypass Feeders: Install in closed hydronic systems, including hot-water heating and chilled water, and equipped with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 2. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 3. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 - 4. Install a swing check on the inlet after the isolation valve.

3.3 CONNECTIONS

- A. Where installing piping adjacent to equipment, allow space for service and maintenance.
- B. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Comply with requirements in Section 232116 "Hydronic Piping Specialties."

- C. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523.12 "Ball Valves for HVAC Piping," and Section 230523.13 "Butterfly Valves for HVAC Piping,"
- D. Comply with requirements in Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup-water connections to potable-water systems.
- E. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of hydronic systems' startup procedures.
 - 4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 7. 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 test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 8. Repair leaks and defects with new materials and retest piping until no leaks exist.
- C. Equipment will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Acidity and Alkalinity: ASTM D 1067.
3. Iron: ASTM D 1068.
4. Water Hardness: ASTM D 1126.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.
- B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 232513

SECTION 232923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections:
 - 1. Division 23 Section "Direct Digital Control (DDC) System for HVAC".
 - 2. Division 23 Section "Packaged, Outdoor, Central Station Air Handling Units".
 - 3. Division 23 Section "Hydronic Pumps".

1.2 SUMMARY

- A. Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.
- B. VFCs shall be of same model line by a single manufacturer and shall be furnished and installed as part of Division 23 Section "Instrumentation and Control for HVAC". Installation shall include connection between motor and controller unless explicitly indicated otherwise.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. CPT: Control power transformer.
- C. EMI: Electromagnetic interference.
- D. IGBT: Insulated-gate bipolar transistor.
- E. LAN: Local area network.
- F. LED: Light-emitting diode.
- G. MCP: Motor-circuit protector.
- H. NC: Normally closed.
- I. NO: Normally open.
- J. OCPD: Overcurrent protective device.

- K. PID: Control action, proportional plus integral plus derivative.
- L. PWM: Pulse-width modulated.
- M. RFI: Radio-frequency interference.
- N. VFC: Variable-frequency motor controller.
- O. VFD: Variable-frequency drive, alternative description of VFC.

1.4 SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
- B. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - 1. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Product certificates.
- E. Operation and maintenance data.

1.5 QUALITY ASSURANCE

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

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs 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 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB.
 - 2. Package units with factory installed VFCs can be manufacture's preferred VFC
- B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- C. Application: Variable torque.
- D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
 - 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
- G. Unit Operating Requirements:
 - 1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
 - 2. Input AC Voltage Unbalance: Not exceeding 3 percent.
 - 3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
 - 4. Minimum Efficiency: 96 percent at 60 Hz, full load.
 - 5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
 - 6. Minimum Short-Circuit Current (Withstand) Rating: 10 kA.
 - 7. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 104 deg F.
 - 8. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F.
 - 9. Humidity Rating: Less than 95 percent (noncondensing).

10. Altitude Rating: Not exceeding 3300 feet.
 11. Vibration Withstand: Comply with IEC 60068-2-6.
 12. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
 13. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
 14. Speed Regulation: Plus or minus 5 percent.
 15. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
 16. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- H. Inverter Logic: Microprocessor based, 16 or 32 bit, isolated from all power circuits.
- I. Isolated Control Interface: Allows VFCs to follow remote-control electrical signal over a minimum 40:1 speed range.
- J. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 0.1 to 999.9 seconds.
 4. Deceleration: 0.1 to 999.9 seconds.
 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- K. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
 2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 3. Under- and overvoltage trips.
 4. Inverter overcurrent trips.
 5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
 6. Critical frequency rejection, with three selectable, adjustable deadbands.
 7. Instantaneous line-to-line and line-to-ground overcurrent trips.
 8. Loss-of-phase protection.
 9. Reverse-phase protection.
 10. Short-circuit protection.
 11. Motor overtemperature fault.
- L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

- N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- P. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker or NEMA AB 1, molded-case switch, with power fuse block and current-limiting fuses or NEMA AB 1, thermal-magnetic circuit breaker or NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses or NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.
 - 1. Disconnect Rating: Not less than 115 percent of VFC input current rating.

2.2 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.
- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
 - 1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 - 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
 - 1. Running log of total power versus time.
 - 2. Total run time.
 - 3. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:

1. Electric Input Signal Interface:
 - a. A minimum of two programmable analog inputs: 0- to 10-V dc or 4- to 20-mA dc.
 - b. A minimum of six multifunction programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
3. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc or 4- to 20-mA dc, which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).
 - d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
4. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.

F. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.

1. Network Communications Ports: Ethernet and RS-422/485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet; protocols accessible via the communications ports.

2.3 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 1. Dry and Clean Indoor Locations: Type 1.
 2. Other Wet or Damp Indoor Locations: Type 3R or Type 4, as required.
 3. Exterior Locations, Including Under Canopy: Type 3R.
- B. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

2.4 ACCESSORIES

- A. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
 1. Push Buttons, Pilot Lights, and Selector Switches: Standard-duty type.
 - a. Push Buttons: Shielded types; momentary.
 - b. Pilot Lights: Incandescent or LED types; push to test.
 - c. Selector Switches: Rotary type.
- B. Control Relays: Auxiliary and solid-state time-delay relays.
- C. Monitoring Contacts: Auxiliary dry contacts for monitoring by EMCS as indicated.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
 1. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

- B. VFD's for use with Division 23 Section "Packaged, Outdoor, Central Station Air Handling Units" shall be furnished to AHU manufacturer for factory installation.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in each fusible-switch VFC.
- E. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses."
- F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- H. Comply with NECA 1.

3.2 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 23 Section "Identification for HVAC piping & equipment."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.

3.3 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable.
 - 1. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Architect before increasing settings.
- D. VFD adjustment will involve a combination of balancer, controls contractor, mechanical contractor and startup/commissioning.
- E. VFD startups will be performed by factory authorized representative.

3.5 DEMONSTRATION

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

END OF SECTION 232923

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Duct liner.
 - 5. Sealants and gaskets.
 - 6. Hangers and supports.
 - 7. Seismic-restraint devices.

- B. Related Sections:

- 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible", ASCE/SEI 7, SMACNA's "Round Industrial Duct Construction Standards."
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Sustainable Design Submittals:

1. Product Data: For adhesives, indicating VOC content.
2. Laboratory Test Reports: For adhesives, indicating compliance with requirements for low-emitting materials.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- B. Welding Qualifications: Qualify procedures and personnel according to the following:
 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
 3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- D. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Ductmate Industries, Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO LLC.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
 - 3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
- D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- F. Factory- or Shop-Applied Antimicrobial Coating:
 - 1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
 - 2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 - 3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
 - 4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 5. Shop-Applied Coating Color: White.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- G. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- H. 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.

2.4 DUCT LINER

- A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation.
 - b. Johns Manville; a Berkshire Hathaway company.
 - c. Knauf Insulation.
 2. Thermal Requirements
 - 1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 3. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 4. Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - a. Adhesive shall have a VOC content of 80 g/L or less.
 - b. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- B. Insulation Pins and Washers:
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.

4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
6. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely; at 3 inches from transverse joints and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
9. 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.

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:
 1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 3 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
 10. Sealant shall have a VOC content of 420 g/L or less.
 11. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
- C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. Sealant shall have a VOC content of 420 g/L or less.
9. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."
10. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. Sealant shall have a VOC content of 420 g/L or less.
7. Sealant shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.7 SEISMIC-RESTRAINT DEVICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. B-line, an Eaton business.
 - 2. Ductmate Industries, Inc.
 - 3. Mason Industries, Inc.
- B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
- D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

- E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- 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. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
- D. Installation of grease duct shall comply with requirements of 2014 OMSC, Chapter 5.

3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Outdoor, Exhaust Ducts: Seal Class C.
 - 4. Outdoor, Return-Air Ducts: Seal Class C.
 - 5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
 - 6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.

7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7.
 1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
 2. Brace a change of direction longer than 12 feet.

- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on ducts that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
 - a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
 - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DUCT CLEANING

A. Clean new duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.

2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.11 START UP

- A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

- A. Fabricate ducts with galvanized sheet steel except as otherwise indicated.

B. Supply Ducts:

1. Ducts Connected downstream of Terminal Units (VAV-X):
 - a. Pressure Class: Positive 1-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Variable-Air-Volume Air-Handling Units (RTU-X, AHU-X, MAU-X):
 - a. Pressure Class: Positive 4-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 3.
 - d. SMACNA Leakage Class for Round and Flat Oval: 3.
3. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Return Ducts:

1. Ducts Connected to Air-Handling Units (RTU-X, AHU-X, MAU-X):
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
2. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 3.
 - d. SMACNA Leakage Class for Round and Flat Oval: 3.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air (EF-X):
 - a. Pressure Class: Negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.

2. Ducts Connected to Air-Handling Units (RTU-X, AHU-X, MAU-X):
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 3.
 3. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96 (EF-133A).
 - a. Exposed to View: Type 304, stainless-steel sheet, No. 3 finish.
 - b. Concealed: Type 304, stainless-steel sheet, No. 2D finish.
 - c. Welded seams and joints.
 - d. Pressure Class: Positive or negative 3-inch wg.
 - e. Airtight/Watertight.
 4. Ducts Connected to Dishwasher Hoods (EF-133B):
 - a. Type 304, stainless-steel sheet.
 - b. Exposed to View: No. 3 finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and flanged joints with watertight EPDM gaskets.
 - e. Pressure Class: Positive or negative 2-inch wg.
 - f. Airtight/Watertight.
 5. Ducts Connected to Fans Exhausting Process (ASHRAE 62.1, Class 3 and 4) Air (EF-#):
 - a. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
 - b. Pressure Class: Positive or negative 3-inch wg.
 - c. Minimum SMACNA Seal Class: A.
 - d. SMACNA Leakage Class 3.
 6. Ducts Connected to Equipment Not Listed Above:
 - a. Pressure Class: Positive or negative 2-inch wg.
 - b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 3.
- E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
1. Ducts Connected to Air-Handling Units (RTU-X, AHU-X, MAU-X):
 - a. Pressure Class: Positive or negative 3-inch wg.
 - b. Minimum SMACNA Seal Class: A.
 - c. SMACNA Leakage Class for Rectangular: 6.
 - d. SMACNA Leakage Class for Round and Flat Oval: 3.
 2. Ducts Connected to Equipment Not Listed Above:

- a. Pressure Class: Positive or negative 2-inch wg.
- b. Minimum SMACNA Seal Class: A.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.

F. Intermediate Reinforcement:

- 1. Galvanized-Steel Ducts: Galvanized steel.
- 2. PVC-Coated Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.
- 3. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.
 - b. Not Exposed to Airstream: Match duct material.

G. Liner - Only Where Indicated:

- 1. Supply Air Ducts: Fibrous glass, Type I, 1 inch thick.
- 2. Return Air Ducts: Fibrous glass, Type I, 1 inch thick.
- 3. Transfer Ducts: Fibrous glass, Type I, 1 inch thick.

H. Elbow Configuration:

- 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
- 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1500 fpm or Lower: Conical tap.
 - b. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Backdraft dampers.
2. Pressure relief access doors.
3. Manual volume dampers.
4. Control dampers.
5. Flange connectors.
6. Turning vanes.
7. Duct-mounted access doors.
8. Flexible connectors.
9. Duct accessory hardware.

- B. Related Requirements:

1. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.
2. Section 233423 "HVAC Power Ventilators" for roof-mounted ventilator caps.
3. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
 - a. Special fittings.
 - b. Manual volume damper installations.
 - c. Control-damper installations.
 - d. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

- A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G60.
 - 2. Exposed-Surface Finish: Mill phosphatized.
- B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and No. 4 finish for exposed ducts.
- C. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- D. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 BACKDRAFT DAMPERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Air Balance Inc.
 - 2. Greenheck Fan Corporation.
 - 3. Nailor Industries Inc.
 - 4. Pottorff.

- 5. Ruskin Company.
 - B. Description: Gravity balanced.
 - C. Maximum Air Velocity: 2000 fpm.
 - D. Maximum System Pressure: 1-inch wg.
 - E. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.
 - F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.
 - G. Blade Action: Parallel.
 - H. Blade Seals: Neoprene, mechanically locked.
 - I. Blade Axles:
 - 1. Material: Nonferrous metal.
 - 2. Diameter: 0.20 inch.
 - J. Tie Bars and Brackets: Aluminum.
 - K. Return Spring: Adjustable tension.
 - L. Bearings: Steel ball or synthetic pivot bushings.
 - M. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Electric actuators.
 - 4. Chain pulls.
 - 5. Screen Mounting: Rear mounted.
 - 6. Screen Material: Galvanized steel.
 - 7. Screen Type: Bird.
 - 8. 90-degree stops.
- 2.4 PRESSURE RELIEF ACCESS DOOR
- A. Pressure Relief Access Door:
 - 1. Door and Frame Material: Galvanized sheet steel.
 - 2. Door: Double wall with metal thickness applicable for duct pressure class.
 - 3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
 - 4. Factory set to activate at a 0.5" higher than duct static pressure classification.
 - 5. Doors close when pressures are within set-point range.

6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch thick, fibrous-glass or polystyrene-foam board.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Air Balance Inc.
 - b. Flexmaster U.S.A., Inc.
 - c. MetalAire, Inc.
 - d. Nailor Industries Inc.
 - e. Pottorff.
 - f. Ruskin Company.
 - g. Trox USA Inc.
 - h. Vent Products Co., Inc.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Frame: 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.
 - 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. Standard, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Air Balance Inc.
 - b. Flexmaster U.S.A., Inc.
 - c. MetalAire, Inc.
 - d. Nailor Industries Inc.
 - e. Pottorff.
 - f. Ruskin Company.
 - g. Trox USA Inc.
 2. Standard leakage rating, with linkage outside airstream.
 3. Suitable for horizontal or vertical applications.
 4. Frames: Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with 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. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
 - e. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
 6. Blade Axles: Galvanized steel.
 7. Bearings:
 - a. Oil-impregnated bronze.
 - 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: Aluminum.
- C. Jackshaft:
1. Size: 1-inch diameter.
 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
- D. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
 2. Include center hole to suit damper operating-rod size.
 3. Include elevated platform for insulated duct mounting.

2.6 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ.
 - 3. Ward Industries; a brand 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.

2.7 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. MetalAire, Inc.
 - 4. SEMCO LLC.
 - 5. Ward Industries; a brand 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.
 - 1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall.

2.8 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. CESCO Products; a division of MESTEK, Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Flexmaster U.S.A., Inc.
 - 4. Greenheck Fan Corporation.
 - 5. Nailor Industries Inc.

6. Pottorff.

- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

- a. Double wall, rectangular.
- b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
- c. Vision panel.
- d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
- e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

3. Number of Hinges and Locks:

- a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
- b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
- c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
- d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.9 DUCT ACCESS PANEL ASSEMBLIES

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

1. 3M.
2. Ductmate Industries, Inc.
3. Flame Gard, Inc.

- B. Labeled according to UL 1978 by an NRTL.

- C. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

- D. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.10 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. Ventfabrics, Inc.
 - 4. Ward Industries; a brand 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 two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40 to plus 200 deg F.
- 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.
- G. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
 - 1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 - 2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
 - 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.11 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
 - 3. Volume dampers not required between AHU discharge and VAV terminal units.
- D. Set dampers to fully open position before testing, adjusting, and balancing.
- E. Install test holes at fan inlets and outlets and elsewhere as indicated.
- F. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. Install pressure relief access door between air handling unit and first wall and/or floor penetration.
 - 2. Elsewhere as indicated.
- G. Install access doors with swing against duct static pressure.
- H. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.

5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.
- I. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- J. Install flexible connectors to connect ducts to equipment.
- K. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- L. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- M. Connect diffusers or light troffer boots to low-pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- N. Connect flexible ducts to metal ducts with liquid adhesive plus tape.
- O. Install duct test holes where required for testing and balancing purposes.
- P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.
- Q. Install pressure relief access door between unit connection and first branch on supply and return for each air handling unit (AHU).
- R. Install acoustic turning vanes in all supply, return and exhaust system mitered elbows 45 degrees and larger and as indicated. Do not install turning vanes in commercial kitchen hood exhaust duct.

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. Inspect turning vanes for proper and secure installation.
 4. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233346 - FLEXIBLE DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Insulated flexible ducts.

1.3 ACTION SUBMITTALS

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

- B. Sustainable Design Submittals:

- 1. Product data showing compliance with ASHRAE 62.1.
 - 2. Product Data: For adhesives and sealants, indicating VOC content.
 - 3. Laboratory Test Reports: For adhesives and sealants, indicating compliance with requirements for low-emitting materials.
 - 4. Laboratory Test Reports: For Insulation, indicating compliance with requirements for low-emitting materials.
 - 5. Product Data : For insulation, indicating that R-values comply with tables in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

- C. Shop Drawings: For flexible ducts.

- 1. Include plans showing locations and mounting and attachment details.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from installers of the items involved.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- C. Comply with the Air Diffusion Council's "ADC Flexible Air Duct Test Code FD 72-R1."
- D. Comply with ASTM E 96/E 96M, "Test Methods for Water Vapor Transmission of Materials."

2.2 INSULATED FLEXIBLE DUCTS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on drawings or comparable product by one of the following:
 - 1. Flexmaster USA, Inc
 - 2. JP Lamborn Co.
 - 3. McGill Airflow LLC
- B. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; aluminized vapor-barrier film.
 - 1. Pressure Rating: 8-inch wg positive or negative.
 - 2. Maximum Air Velocity: 5000 fpm.
 - 3. Temperature Range: Minus 20 to plus 250 deg F.
 - 4. Insulation R-Value: R8.

2.3 FLEXIBLE DUCT CONNECTORS

- A. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
- B. Non-Clamp Connectors: Liquid adhesive plus tape.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install flexible ducts according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install in indoor applications only. Flexible ductwork should not be exposed to UV lighting.
- C. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
- D. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.
- E. Connect flexible ducts to metal ducts with draw bands.
- F. Install duct test holes where required for testing and balancing purposes.
- G. Installation:
 - 1. Install ducts fully extended.
 - 2. Do not bend ducts across sharp corners.
 - 3. Bends of flexible ducting shall not exceed a minimum of one duct diameter.
 - 4. Avoid contact with metal fixtures, water lines, pipes, or conduits.
 - 5. Install flexible ducts in a direct line, without sags, twists, or turns.
- H. Supporting Flexible Ducts:
 - 1. Suspend flexible ducts with bands 1-1/2 inches wide or wider and spaced a maximum of 48 inches apart. Maximum centerline sag between supports shall not exceed 1/2 inch per 12 inches.
 - 2. Install extra supports at bends placed approximately one duct diameter from center line of the bend.
 - 3. Ducts may rest on ceiling joists or truss supports. Spacing between supports shall not exceed the maximum spacing per manufacturer's written installation instructions.
 - 4. Vertically installed ducts shall be stabilized by support straps at a maximum of 72 inches o.c.

END OF SECTION 233346

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Backward-inclined centrifugal fans, including airfoil and curved blade fans.
 - 2. Forward-curved centrifugal fans.
 - 3. Square in-line centrifugal fans.
 - 4. Tubular in-line centrifugal fans.
 - 5. Plenum fans.
 - 6. Plug fans.
 - 7. Utility set fans.

1.3 ACTION SUBMITTALS

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

- 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Certified fan performance curves with system operating conditions indicated.
 - 4. Certified fan sound-power ratings.
 - 5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 6. Material thickness and finishes, including color charts.
 - 7. Dampers, including housings, linkages, and operators.

- B. Shop Drawings:

- 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
- C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Fan room layout and relationships between components and adjacent structural and mechanical elements, drawn to scale, and coordinated with each other, using input from installers of the items involved.
- B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity, and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For centrifugal fans to include in normal operation, emergency operation, and maintenance manuals with replacement parts listing.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolators and supports.

- B. Seismic Performance: Centrifugal fans 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."
 - 2. Component Importance Factor: 1.0.
- C. Capacities and Characteristics:
 - 1. As indicated on drawings.

2.2 SQUARE IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Acme Engineering & Mfg. Corp.
 - 2. Loren Cook Company
 - 3. Penn Barry Ventilation
 - 4. Twin City Blower
 - 5. Greenheck.
- B. Description: Direct- or belt-driven centrifugal cabinet fans.
- C. Construction: Minimum 18 gauge galvanized steel. Internal blower and motor assembly mounted on rubber vibration isolators. Integral duct collars.
- D. Fan Wheels: Steel hub and wheel.
- E. Belt-Driven Assembly: Resiliently mounted to housing, with the follow 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. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent, factory wired, direct drive fans only.
 - 2. Additional Accessories: As indicated.

2.3 UTILITY SET FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Carnes Company.
 - 2. Hartzell Fan Incorporated.
 - 3. Greenheck

4. JencoFan.
 5. Loren Cook Company.
 6. PennBarry.
 7. Quietaire Inc.
 8. Trane; a business of American Standard Companies.
- B. Housing: Fabricated of galvanized steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
1. Housing Discharge Arrangement: Adjustable to eight standard positions.
- C. Fan Wheels: Single-width, single inlet, with hub keyed to shaft.
1. Blade Materials: Aluminum.
 2. Coated with Hi-Pro polyester
 3. Blade Type: Backward inclined.
 4. Weatherhood.
 5. Spark-Resistant Construction: AMCA 99, Type A.
- D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
- E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L₅₀ of 200,000 hours.
1. Extend grease fitting to accessible location outside of unit.
- F. Belt Drives:
1. Factory mounted, with final alignment and belt adjustment made after installation
 2. Service Factor Based on Fan Motor Size: 1.3.
 3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- G. Accessories:
1. Inlet and Outlet: Flanged.
 2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
 3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
 4. Access Door: Gasketed door in scroll with latch-type handles.
 5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
 6. Inlet Screens: Removable wire mesh.
 7. Drain Connections: NPS 3/4 threaded coupling drain connection installed at lowest point of housing.
 8. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.

9. Discharge Dampers: Assembly with opposed blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
10. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
11. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

H. Capacities and Characteristics: See schedule

1. Vibration Isolators:
 - a. Type: Spring isolators.
 - b. Static Deflection: 2 inches.
2. Spark Arrestance Class: A.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
- B. Where variable-frequency drives are indicated or scheduled, provide fan motor compatible with variable-frequency drive.

2.5 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. AMCA Compliance: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.
- C. Fan Sound Ratings: Comply with AMCA 311 and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.
- D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.
- E. Operating Limits: Classify fans according to AMCA 99.

PART 3 - EXECUTION

3.1 INSTALLATION OF CENTRIFUGAL HVAC FANS

- A. Install centrifugal fans level and plumb.
- B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.
- D. Equipment Mounting:
 - 1. Install floor- or roof-mounted centrifugal fans on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 - 2. Support duct-mounted and other hanging centrifugal fans directly from the building structure, using suitable hanging systems as specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 3. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 4. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- E. Curb Support, Field Built-Up: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," detail "Equipment Support Curb," number "SPF-9" (page 1409) and detail "Equipment Support Curb," number "SPF-9S" (page 1410). Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
- F. Curb Support, Prefabricated: Rail-type wood support provided by fan manufacturer.
- G. Unit Support: Install centrifugal fans level on structural curbs. Coordinate wall penetrations and flashing with wall construction.
- H. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install flexible duct connectors and vibration-isolation and seismic-control devices.
 - 1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
 - 2. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for vibration-isolation and seismic-control devices.
- I. Install units with clearances for service and maintenance.
- J. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK AND PIPING CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."
- B. Install ducts adjacent to fans to allow service and maintenance.
- C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 ELECTRICAL CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
- E. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

3. Verify that there is adequate maintenance and access space.
 4. Verify that cleaning and adjusting are complete.
 5. 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.
 6. Adjust belt tension.
 7. Adjust damper linkages for proper damper operation.
 8. Verify lubrication for bearings and other moving parts.
 9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 10. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
 11. Remove and replace malfunctioning units and retest as specified above.
- F. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "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.

3.7 DEMONSTRATION

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

END OF SECTION 233416

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Centrifugal ventilators - roof upblast and sidewall.

1.3 ACTION SUBMITTALS

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

- 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes for fans.
 - 2. Rated capacities, operating characteristics, and furnished specialties and accessories.
 - 3. Certified fan performance curves with system operating conditions indicated.
 - 4. Certified fan sound-power ratings.
 - 5. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 6. Material thickness and finishes, including color charts.
 - 7. Dampers, including housings, linkages, and operators.
 - 8. Prefabricated roof curbs.
 - 9. Fan speed controllers.

- B. Shop Drawings:

- 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.

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

- 1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, or BIM model, drawn to scale, showing the items described in this Section and coordinated with all building trades.
- B. Seismic Qualification Data: For fans, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC power ventilators to include in normal and emergency operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design vibration isolation and seismic restraints, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Seismic Performance: HVAC power ventilators shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
 - 2. Component Importance Factor: 1.0.
- C. Capacities and Characteristics:

1. As indicated on drawings.

2.2 CENTRIFUGAL VENTILATORS - ROOF DOWNBLAST

- A. Housing: Downblast; removable spun-aluminum dome top and outlet baffle; square, one-piece aluminum base with venturi inlet cone.
- B. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- C. Belt Drives:
 1. Resiliently mounted to housing.
 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
 6. Fan and motor isolated from exhaust airstream.
- D. Accessories:
 1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted 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.
 5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 6. Spark-resistant, all-aluminum wheel construction.
 7. Mounting Pedestal: Galvanized steel with removable access panel.
- E. Prefabricated Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch-thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
 1. Configuration: Built-in cant and mounting flange.
 2. Overall Height: 12 inches.
 3. Sound Curb: Curb with sound-absorbing insulation.
 4. Hinged sub-base to provide access to damper or as cleanout for grease applications.
 5. Pitch Mounting: Manufacture curb for roof slope.
 6. Metal Liner: Galvanized steel.
 7. Mounting Pedestal: Galvanized steel with removable access panel.

2.3 CENTRIFUGAL VENTILATORS - ROOF UPBLAST OR SIDEWALL

- A. Configuration: Centrifugal roof upblast, grease hood kitchen ventilator.
- B. 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.
 - 2. Provide grease collector.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades; sparkproof construction.
- D. Belt Drives:
 - 1. Resiliently mounted to housing.
 - 2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings; minimum ABMA9, L(10) of 100,000 hours.
 - 4. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 - 5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions. Provide fixed pitch for use with motors larger than 5 hp.
 - 6. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 - 1. Variable-Frequency Motor Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted 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.
 - 5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
 - 6. Spark-resistant, all-aluminum wheel construction.
 - 7. Mounting Pedestal: Galvanized steel with removable access panel.
 - 8. Wall Mount Adapter: Attach wall-mounted fan to wall.
 - 9. Restaurant Kitchen Exhaust: UL 762 listed for grease-laden air exhaust.
- F. Prefabricated Kitchen Exhaust Roof Curbs: Galvanized steel; mitered and welded corners; ventilation openings on all sides to ventilate curb interstitial space. Size as required to suit roof opening and fan base.
 - 1. Configuration: Built-in cant and mounting flange.
 - 2. Overall Height: 18 inches.
 - 3. Sound Curb: Curb with sound-absorbing insulation and galvanized metal liner.
 - 4. Hinged sub-base to provide access to damper or as cleanout for grease applications.

5. Pitch Mounting: Manufacture curb for roof slope.
6. Metal Liner: Galvanized steel.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Vented Curb: For kitchen exhaust; 12-inch-high galvanized steel; unlined, with louvered vents in vertical sides.
9. NFPA 96 code requirements for commercial cooking operations.
10. Kitchen Hood Exhaust: UL 762 listed for grease-laden air.

2.4 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "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.

2.5 SOURCE QUALITY CONTROL

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. AMCA Certification: Fans shall comply with AMCA 11 and bear the AMCA-Certified Ratings Seal.
- C. Fan Sound Ratings: Comply with AMCA 311, and label fans with the AMCA-Certified Ratings Seal. Sound ratings shall comply with AMCA 301. The fans shall be tested according to AMCA 300.
- D. Fan Performance Ratings: Comply with AMCA 211 and label fans with AMCA-Certified Rating Seal. The fans shall be tested for air performance - flow rate, fan pressure, power, fan efficiency, air density, speed of rotation, and fan efficiency - according to AMCA 210/ASHRAE 51.
- E. Operating Limits: Classify according to AMCA 99.
- F. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

PART 3 - EXECUTION

3.1 INSTALLATION OF HVAC POWER VENTILATORS

- A. Install power ventilators level and plumb.
- B. Equipment Mounting:

1. Install power ventilators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 3. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Secure roof-mounted fans to roof curbs with zinc-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 DUCTWORK CONNECTIONS

- A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

3.4 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections.
- E. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that there is adequate maintenance and access space.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. 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.
 - 6. Adjust belt tension.
 - 7. Adjust damper linkages for proper damper operation.
 - 8. Verify lubrication for bearings and other moving parts.
 - 9. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 10. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 11. Shut unit down and reconnect automatic temperature-control operators.
 - 12. Remove and replace malfunctioning units and retest as specified above.
- F. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Section 230593 "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.

3.7 DEMONSTRATION

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

END OF SECTION 233423

SECTION 233439 - HIGH-VOLUME, LOW-SPEED FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes high-volume, low-speed fans.

1.3 DEFINITIONS

- A. HVLS - High volume, low speed.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, furnished specialties, and accessories for each fan.
 - 2. Certified fan performance curves with system operating conditions indicated.
 - 3. Certified fan sound-power ratings.
 - 4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 5. Material thickness and finishes, including color charts.
 - 6. Fan speed controllers.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Show dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For each HVLS fan.
 - 1. Include design calculations and details for selecting product mounting components and seismic restraints complying with performance requirements, design criteria, and analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 2. Design Calculations: Calculate static and dynamic loading due to equipment weight, operation, and seismic forces required to select mounting components and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and details, drawn to scale and coordinated with each other, using input from installers of the items involved.
- B. Qualification Data:
 - 1. For Installer: Certificate from HVLS fan manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, controls, and accessories indicated and furnished for installation.
- C. Seismic-Restraint Details:
 - 1. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - 2. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - 3. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- D. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVLS fans to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Provide certification that manufacturer complies with the requirements of the most recent edition of ISO 9001.
- B. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by HVLS fan manufacturer.
 - 1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, controls, and accessories indicated and furnished for installation.
 - 2. Installer certification shall be valid and current for duration of Project.
 - 3. Retain copies of Installer certificates on-site and make available on request.
 - 4. Each person assigned to Project shall have demonstrated past experience.

- a. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 - b. Demonstrated past experience on five projects of similar complexity, scope, and value.
5. Installers shall have staffing resources of competent, trained, and experienced full-time employees that are assigned to execute work according to schedule.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean and dry place.
- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
- E. Replace installed products damaged during construction.

1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of fans that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Motor, Including Controls: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Blades and Hub: Five year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

- B. UL Compliance: Listed and labeled to UL 507.
- C. CSA Compliance: Listed and labeled to CSA C22.2, No. 113.
- D. Comply with NFPA 13 requirements for HVLS fans.
- E. AMCA Compliance:
 - 1. Test HVLS fans according to AMCA 230.
 - 2. Certify HVLS fan performance according to AMCA 211.
- F. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.
- G. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design HVLS ceiling fans.
- H. Seismic Performance: HVLS ceiling fans shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the HVLS fans will remain in place without separation of any parts when subjected to the seismic forces specified."
 - 2. Component Importance Factor: 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

- 1. See plans.

2.3 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Big Ass Fans.
- B. Source Limitations: Obtain HVLS fans from single source from single manufacturer.

2.4 HIGH-VOLUME, LOW-SPEED FANS

- A. Description: Factory-assembled and -tested horizontal, non-ducted fan unit, consisting of large-diameter blade set, direct-drive electric motor, with variable-speed motor controller.
 - 1. Provide fan designed to circulate large air volume, vertically, at low velocity.
 - 2. Maximum Operating Temperature: 122 deg F.
 - 3. Frame:
 - a. Material: Aluminum.

- 1) Finish: Paint.
- 4. Diameter: 12 feet.
- 5. Blades: Airfoil type.
 - a. Quantity: 8.
 - b. Material: Aluminum.
- 1) Blade Finish: Anodized.
- 6. Motor: , integral to fan frame.
- 7. Wiring and Controls Enclosure:
 - a. NEMA 250, Class 1.
 - b. Material: Aluminum.
- 1) Enclosure Finish: Paint.
- c. Grounded.
- 8. Controls: Provide wall-mounted keypad.
 - a. Provide fixed speed control.
- 9. Maximum Sound Power Level: 50 dBA.
- 10. Standard Mounting Bracket: Steel beam/steel angle.
- 11. Mounting Bracket: Large beam.
- 12. Accessories:
 - a. Mounting extension tube.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with requirements for installation tolerances and other conditions affecting HVLS fan performance, maintenance, and operations.
 - 1. Fan locations indicated on Drawings are approximate. Determine exact locations before roughing-in for mounting, control, and electrical connections.
- B. Examine roughing-in for mounting location, anchor-bolt sizes, and locations, to verify actual locations for mounting connections before installation of fan.
- C. Examine areas for suitable conditions where fan will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION OF HIGH-VOLUME LOW-SPEED FANS

- A. Install fan according to manufacturer's published instructions.
- B. Comply with NECA 1 and NFPA 70.
- C. Comply with NFPA 13 for installation of HVLS fans and maximum allowable fan diameter. Center HVLS fans between four adjacent sprinklers. Minimum vertical clearance from HVLS fan to sprinkler deflector is 3 feet.
- D. Comply with NFPA 72 and interlock HVLS fans to shut down upon receiving an alarm from fire alarm system.
- E. Equipment Mounting:
 - 1. Anchor fan to building structure with manufacturer's recommended mounting bracket as shown in approved delegated design for installed condition.
 - 2. Consult a licensed professional structural engineer for mounting methods and approval for mounting to the structure. Structure must be able to withstand the torque and forces generated by the fan.
 - 3. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
 - 4. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
 - 5. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- F. Install unit to permit access for maintenance.
- G. Install parts and accessories shipped loose.

3.3 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.

- E. Install power wiring to field-mounted electrical devices, furnished by fan manufacturer, but not factory mounted.

3.4 CONTROL CONNECTIONS

- A. Connect control wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."
- C. Connect control interlock wiring between HVLS fan and other equipment to provide a complete and functioning system.
- D. Connect control wiring between fan unit control interface and control system to provide remote control and monitoring.
- E. Install control devices furnished by manufacturer, but not factory mounted.
- F. Install control wiring to field-mounted control devices, furnished by fan manufacturer, but not factory mounted.
- G. Protect installed units from damage caused by other work.

3.5 FIELD QUALITY CONTROL

- A. Testing Agency, Owner Engaged: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency, Contractor Engaged: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Fan or components will be considered defective if fan or components do not pass tests and inspections.
- F. Prepare and submit test and inspection reports.

3.6 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that fan is secure on mountings and supporting devices and that connections to electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers and switches.
 - 3. Verify proper motor rotation direction and free fan rotation.
 - 4. Check bearing and gearbox lubrication.
 - 5. Verify proper fan rotation. Set rotation selector to blow vertically downward during heating season, and vertically upward during cooling season.

3.7 ADJUSTING

- A. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.8 CLEANING

- A. Clean equipment externally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions. Following manufacturer's cleaning procedures, and clean with manufacturer-recommended cleaning products.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVLS fans.
- B. Video training sessions, and provide electronic copy of video to Owner.

END OF SECTION 233439

SECTION 233533 - LISTED KITCHEN VENTILATION SYSTEM EXHAUST DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Listed grease ducts.
- 2. Access doors.

1.3 ACTION SUBMITTALS

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

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for listed grease ducts.

- B. Shop Drawings: For listed grease ducts.

- 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. Detail fabrication and assembly of hangers and seismic restraints.

1.4 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:

- 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
- 2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in listed grease ducts and field-fabricated grease ducts.

PART 2 - PRODUCTS

2.1 LISTED GREASE DUCTS

- A. Description: Factory-fabricated, -listed, and -labeled, double-wall ducts tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.
- B. Construction: Inner shell and outer jacket separated by at least a 1-inch annular space filled with high-temperature, ceramic-fiber insulation.
 - 1. Inner Shell: ASTM A 666, Type 316 stainless steel.
 - 2. Outer Jacket: Stainless steel where concealed. Stainless steel where exposed.
- C. Gaskets and Flanges: Ensure that gaskets and sealing materials are rated at 1500 deg F minimum.
- D. Hood Connectors: Constructed from same material as grease duct with internal or external continuously welded or brazed joints.
- E. Accessories: Tees, elbows, increasers, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters, and drain fittings.
- F. Grease Duct Supports: Construct duct bracing and supports from non-combustible material.
 - 1. Design bracing and supports to carry static and seismic loads within stress limitations of the International Building Code.
 - 2. Ensure that bolts, screws, rivets and other mechanical fasteners do not penetrate duct walls.
- G. Comply with ASTM E 2336.
- H. Factory Tests: Test and inspect fire resistance of grease duct system according to ASTM E 2336.

2.2 ACCESS DOORS

- A. Description: Factory-fabricated, -listed, and -labeled, double-wall maintenance access doors tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.
 - 1. Construction: 0.0625 inch ASTM A 666, Type 316 stainless-steel inner shell and stainless-steel outer cover with two handles.
 - 2. Fasteners: Stainless-steel bolts and wing nuts.

- a. Ensure that bolts do not penetrate interior of duct space.
3. Maintenance Access Door Dimensions: 7 x 7 inches.
4. Personnel Access Door Dimensions: 24 x 24 inches.
5. Door Label: Mark door with uppercase lettering as follows: "ACCESS PANEL. DO NOT OBSTRUCT."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. Comply with requirements in Section 077200 "Roof Accessories."
- B. Coordinate connections to exhaust fans with requirements in Section 233423 "HVAC Power Ventilators."
- C. Coordinate firestopping where grease ducts penetrate fire separations with requirements in Section 078413 "Penetration Firestopping."
- D. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211 and UL 2221, whichever is most stringent.
- E. Install airtight maintenance access doors where indicated.
- F. Seal between sections of grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- G. Connections: Make grease duct connections according to the International Mechanical Code.
 1. Grease duct to exhaust fan connections: Connect grease ducts to inlet side of fan using flanges, gaskets, and bolts.
 2. Grease duct to hood connections:
 - a. Make grease duct to hood joints connections using internal or external continuously welded or brazed joints.
 - b. Make watertight grease duct to hood joints connections using flanges, gaskets, and bolts.
- H. Support ducts at intervals recommended by manufacturer to support weight of ducts and accessories, without applying loading on kitchen hoods.

1. Securely attach supports and bracing to structure.

- I. Grease Duct Enclosures: Comply with requirements of the International Building Code and ASTM E 2336.
- J. Coordinate fire-rated enclosure construction with Section 092116.23 "Gypsum Board Shaft Wall Assemblies."
- K. Repair damage to adjacent materials caused by listed kitchen ventilation system exhaust ducts installation.

3.3 FIELD QUALITY CONTROL

- A. Perform air leakage test before concealment of any portion of the grease duct system.

END OF SECTION 233533

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Shutoff, single-duct air terminal units.

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and support and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards – Metal and Flexible" and ASCE/SEI 7.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For air terminal units.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include diagrams for power, signal, and control wiring.
 - 4. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
- C. Delegated-Design Submittal:
 - 1. Materials, fabrication, assembly, and spacing of hangers and supports.

2. Include design calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.
 1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Instructions for resetting minimum and maximum air volumes.
 - b. Instructions for adjusting software set points.

1.7 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

- A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable products by one of the following:
 1. ENVIRO-TEC; by Johnson Controls, Inc.
 2. Nailor Industries Inc.
 3. Titus.
- B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 22 gauge zinc coated steel double wall.
 1. Casing Liner: Adhesive attached, 3/4-inch thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 3. Air Outlet: S-slip and drive connections.
 4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: AHRI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
- E. Hydronic Heating Coils: 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 valve.
- F. Direct Digital Controls: Factory mount actuator specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."

1.8 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to AHRI 880.
 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and AHRI certification seal.

PART 2 - EXECUTION

2.1 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Ch. 5, "Hangers and Supports" and with Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inchesthick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches thick.
 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.2 SEISMIC-RESTRAINT-DEVICE INSTALLATION

- A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with ASCE/SEI 7. Comply with requirements for seismic-restraint devices in Section 230548 "Vibration and Seismic Controls for HVAC."

- B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
- C. Install cables so they do not bend across edges of adjacent equipment or building structure.
- D. Install cable restraints on air terminal units that are suspended with vibration isolators.
- E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.
- F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
- G. Drilling for and Setting Anchors:
 - 1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

2.3 TERMINAL UNIT INSTALLATION

- A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
- C. Install wall-mounted thermostats.

2.4 CONNECTIONS

- A. Where installing piping adjacent to air terminal unit, allow space for service and maintenance.
- B. Hot-Water Piping: Comply with requirements in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties," and connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

- C. Comply with requirements in Section 233113 "Metal Ducts" for connecting ducts to air terminal units.
- D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

2.5 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

2.6 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:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air terminal unit will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

2.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.

2.8 DEMONSTRATION

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

END OF SECTION 233600

SECTION 233713.13 - AIR DIFFUSERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Rectangular and square ceiling diffusers.
 - 2. Linear slot diffusers.

- B. Related Requirements:

- 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers.
 - 2. Section 233713.23 "Air Registers and Grilles" for adjustable-bar register and grilles, fixed-face registers and grilles, and linear bar grilles.

1.3 ACTION SUBMITTALS

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

- 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

PART 2 - PRODUCTS

2.1 RECTANGULAR AND SQUARE CEILING DIFFUSERS

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

- 1. Carnes Company.
 - 2. Nailor Industries Inc.
 - 3. Titus.
 - 4. Price.

- B. Devices shall be specifically designed for variable-air-volume flows.

C. Material: Steel

1. Provide with Aluminum face diffusers in all wet applications (toilets, etc.).

D. Finish: Baked enamel, white.

E. Characteristics: See Drawings.

2.2 LINEAR SLOT DIFFUSERS

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

1. Carnes Company.
2. Nailor Industries Inc.
3. Titus.
4. Price.

B. Devices shall be specifically designed for variable-air-volume flows.

C. Material - Shell: Steel, insulated.

D. Characteristics: See Drawings

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install diffusers level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust diffusers to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.13

SECTION 233713.23 - REGISTERS AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Adjustable blade face registers and grilles.

- B. Related Requirements:

- 1. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to registers and grilles.
 - 2. Section 233713.13 "Air Diffusers" for various types of air diffusers.

1.3 ACTION SUBMITTALS

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

- 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

PART 2 - PRODUCTS

2.1 REGISTERS

- A. Adjustable Blade Face Register:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carnes Company.
 - b. Nailor Industries Inc.
 - c. Titus.
 - d. Price.
 - 2. Material: Steel.

- a. Provide with Aluminum face diffusers in all wet applications (toilets, etc.).
- 3. Finish: Baked enamel, white.
- 4. Characteristics: See Drawings.

2.2 GRILLES

A. Adjustable Blade Face Grille:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Carnes Company.
 - b. Nailor Industries Inc.
 - c. Titus.
 - d. Price.
- 2. Material: Steel
 - a. Provide with Aluminum face diffusers in all wet applications (toilets, etc.).
- 3. Finish: Baked enamel, white.
- 4. Characteristics: See Drawings.

2.3 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate registers and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install registers and grilles level and plumb.
- B. Outlets and Inlets Locations: 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 registers and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.2 ADJUSTING

- A. After installation, adjust registers and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713.23

SECTION 235123 - GAS VENTS

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. Listed double-wall vents.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.
- B. Shop Drawings: For vents.
 - 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. Detail fabrication and assembly of hangers and seismic restraints.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Sample Warranty: For special warranty.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents.

- B. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

PART 2 - PRODUCTS

2.1 LISTED SPECIAL GAS VENTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Heatfab Saf-T Vent.
 2. Metal-Fab, Inc.
 3. Selkirk Corporation.
- B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.
- D. Inner Shell: ASTM A959, Type 29-4C stainless steel.
- E. Outer Jacket: Stainless steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

- A. Listed Special Gas Vent: Condensing gas appliances, including gas-fired domestic water heaters and heating how water boilers.

3.3 INSTALLATION OF LISTED VENTS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."
- B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- E. Lap joints in direction of flow.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 235123

SECTION 235216 - CONDENSING BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, fire-tube or cast iron condensing boilers, trim, and accessories for generating hot water.

1.3 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. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
 - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
 - 2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." 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 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.

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

1.5 CLOSEOUT SUBMITTALS

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

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
- C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
- D. 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.
- E. Gas Train and Safety Controls: conform to requirements of UL 795, CSD-1 and State and Local Code requirements.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.8 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: 20 years from date of Substantial Completion.
 - b. Thermal shock warranty: Lifetime.
 - c. Heat Exchanger Damaged by Corrosion: Non-prorated for five years from date of Substantial Completion.
 - 2. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. 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. Cleaverbrooks.
 - 2. Hydrotherm KN.
 - 3. Buderus.

2.2 FIRE-TUBE CONDENSING BOILERS

- A. Description: Factory-fabricated, -assembled, and -tested, down-fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
- B. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.
- C. Pressure Vessel: Carbon steel with welded heads and tube connections.
- D. Burner: Natural gas, forced draft. The burner shall be capable of a 5:1 gas train turndown without loss of combustion efficiency.

- E. 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 230513 "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.
- F. Gas Train: Combination gas valve with manual shutoff and pressure regulator. The boiler shall be supplied with a gas train designed with negative pressure regulation and shall be capable of a minimum 5:1 turndown.
- G. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
- H. Casing:
 - 1. Jacket: Sheet metal, with snap-in or interlocking closures.
 - 2. Control Compartment Enclosures: NEMA 250, Type 1A.
 - 3. Finish: Baked enamel or powder coated protective finish.
 - 4. Insulation: Minimum 2-inch- thick, mineral fiber insulation surrounding the heat exchanger.
 - 5. Combustion-Air Connections: Inlet and vent duct collars.
 - 6. Mounting base to secure boiler.
 - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" when mounting base is anchored to building structure.
- I. Characteristics and Capacities: As indicated.
- J. Pressure Ratings:
 - 1. Design Water Pressure Rating: 125 psig.
 - 2. Safety Relief Valve Setting: 125 psig.

2.3 TRIM

- A. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
- B. Safety Relief Valve: ASME Section IV rated.
- C. Pressure and Temperature Gage: Minimum 3-1/2-inch- diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
- D. Boiler Air Vent: Manual.

- E. Drain Valve: Minimum NPS 3/4 hose-end gate valve.
- F. Low Water Cut-off: Probe type, manual reset.
- G. Auxiliary Low Water Cut-off: Manual reset.
- H. Temperature Controls: operating controller, modulating controller, high limit controller.

2.4 BOILER MANAGEMENT AND CONTROL

- A. General: Modulating boiler/burner control system. Control may be integral to either boiler with capability of controlling both boilers or may be wall mounted. Integrated digital micro-processor device, sequence indication, fault reset, mode selection, parameter set-point. Touch screen display mounted at front of boiler panel for easy access and viewing. Flame safeguard and boiler control. Control of the following functions:
 - 1. Burner sequencing with safe start check, pre-purge, electronic direct spark ignition, and post purge. Flame rod to prove combustion.
 - 2. Flame Supervision: Pre-purge and post-purge. Maintain a running history of operating hours, number of cycles, and the most recent six faults. Connected to a keyboard display module that will retrieve this information.
 - 3. Safety Shutdown with display of error.
 - 4. Modulating control of variable speed fan for fuel/air input relative to load requirements.
 - 5. Gas pressure supervision, high and low.
 - 6. Combustion Air Proving Supervision.
 - 7. High Air Pressure (back draft too high) Supervision.
 - 8. Supply temperature and set-point temperature displayed at all times by touchscreen readout. Output PID via 4 –20 mA current.
 - 9. BacNET interface.
 - 10. Include programming of system circulating pump and provide the programming of 2 heating loops if required.
 - 11. PID Load control for heating application.
 - 12. Prioritization for demand, rate limiting.
 - 13. Lead/lag control for multiple boilers.
 - 14. Outdoor reset based on signal from EMCS.
 - 15. Boiler isolation valve control.
 - 16. Control transformer.
 - 17. Set-Point Adjust: Set points shall be adjustable from local panel or on signal from EMCS.
- B. Sensors for supply and return water sensing: Required at each boiler.
- C. Boiler management control shall have sequencing control and shall provide staging up to 8 boilers. Control shall include automatic rotation of lead boiler, an adjustable outdoor reset schedule, multiple setback schedules, and digital display. The control shall force each boiler to low fire, before allowing any boiler to operate at high fire. When all boilers are running, all will then be modulated in unison. The control shall be supplied by the boiler supplier, in order to ensure proper integration with the boiler controls.

D. Keyboard Display:

1. Burner Control state, sequence.
2. Rate control, manual adjustment.
3. Lockout code.
4. Alert and hold reason.
5. Heating setpoint.
6. Heating time of day setpoint.
7. First out and system status and diagnostics.
8. Control temperatures.
9. Setup.
10. Flame signal measuring.

- E. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

2.5 COMMUNICATION INTERFACE

- A. Provide communication interface with building automation system to enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.6 ELECTRICAL POWER

- A. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
1. House in NEMA 250, Type 1 enclosure.
 2. Wiring shall be numbered and color-coded to match wiring diagram.
 3. Install factory wiring outside of an enclosure in a metal raceway.
 4. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
 5. Provide each motor with overcurrent protection.

2.7 VENTING KITS

- A. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant. Vent in accordance with Section 235100 – “Breeching, Chimneys, and Stacks.”
- B. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.8 CONDENSATE-NEUTRALIZATION UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Neutra-Safe Corporation.
 2. SFA Saniflo USA.
 3. Skidmore Pump.
 4. Wessels Company.
 5. Condensate-Neutralization Tank by Boiler Mfgr.
- B. Description: Factory-fabricated and -assembled condensate-neutralizing tank assembly of corrosion-resistant plastic material with threaded or flanged inlet and outlet pipe connections. Device functions to prevent acidic condensate from damaging grain system. It is to be piped to receive acidic condensate discharged from condensing boiler and neutralize it by chemical reaction with replaceable neutralizing agent. Neutralized condensate is then piped to suitable drain.
- C. Tank features:
1. All corrosion-resistant material.
 2. Suitable for use on all natural gas and propane boilers.
 3. Includes initial charge of neutralizing agent.
 4. Neutralizing agent to be easily replaceable when exhausted.
 5. Inlet and outlet pipe connections.
- D. Tank Configuration:
1. Utilized where boiler is elevated or where tank is installed in a pit with tank top flush with floor.
 2. Top easily removed for neutralizing agent replacement.
 3. Internal baffles to channel flow for complete neutralization.
 4. Integral bypass to prevent condensate backflow into appliance.
 5. Multiple units may be used for larger capacity.

2.9 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. Equipment Mounting: Install boilers on cast-in-place concrete equipment base(s).
 - 1. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - 2. Construct bases to withstand, without damage to equipment, seismic force required by code.
 - 3. Construct concrete bases 4 inches high and extend base not less than 6 inches in all directions beyond the maximum dimensions of boiler unless otherwise indicated or unless required for seismic anchor support.
 - 4. Minimum Compressive Strength: 5000 psi at 28 days.
 - 5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
 - 7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 8. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Equipment Mounting: Install boilers using elastomeric mounts. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
 - 1. Minimum Deflection: 1/4 inch.
- C. Install gas-fired boilers according to NFPA 54.
- D. Assemble and install boiler trim.
- E. Install electrical devices furnished with boiler but not specified to be factory mounted.
- F. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to boiler to allow service and maintenance.
- C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
- D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Section 232113 "Hydronic Piping."
- E. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
- F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
- G. Install piping from safety relief valves to nearest floor drain.
- H. Boiler Venting:
 - 1. Install flue venting kit and combustion-air intake.
 - 2. Connect full size to boiler connections. Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks."
- 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. Install condensate drain piping to condensate-neutralization unit and from neutralization unit to nearest floor drain. Piping shall be at least full size of connection. Install piping with a minimum of 2 percent downward slope in direction of flow.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Provide detailed written record of start-up performance, including burner setting data over the entire load range. Report shall be furnished to the engineer before acceptance. All labor, equipment and test apparatus shall be furnished by the supplier. All equipment defects discovered by the tests shall be rectified.

B. Tests and Inspections:

1. Delivery Inspection: Boiler representative to provide no less than two 2 hours of on site assistance to inspect boilers and other equipment upon arrival, verifying completeness of equipment supplied and potential damages. All shipped loose components, such as casing, to be mounted on boiler by boiler supplier after contractor has set boiler in building.
2. Pre-start Walk Through: Boiler representative shall provide no less than four (4) hours at jobsite reviewing installation with installing contractor. Conduct walk-through approximately 1 week prior to startup.
3. Start-up: conducted by experienced and factory authorized technician in the regular employment of the boiler supplier, and shall include the following:
 - a. Demonstrate that boiler, burner, controls and accessories comply with requirements of this Section as proposed by the boiler and accessories supplier. Pre-test all items prior to scheduling the final testing that will be witnessed by the test engineer.
 - b. Readings at different firing rates (20, 50, 75 and 100%) of load for the modulating burner shall be taken with a written report of the tests submitted to the engineer. The reports shall include readings for each firing rate tested and shall include stack temperatures, O₂, CO, NO_x, and overall boiler efficiency.
 - c. Auxiliary Equipment and Accessories: Observe and check all valves, draft fans and electric motors, as well as other accessories and appurtenant equipment during the operational and capacity tests for leakage, malfunctions, defects, and non-compliance with referenced standards or overloading as applicable.
4. Perform installation and startup checks according to manufacturer's written instructions.
5. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
6. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
7. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
 - b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

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

D. Occupancy Adjustments: When requested within 15 months of date of Acceptance, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide no less than three 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 Section 017900 "Demonstration and Training."

ACMA
BEAVERTON SCHOOL DISTRICT
BEAVERTON, OREGON

DLR GROUP PROJECT NO. 74-18109-00

BID AND PERMIT SET

END OF SECTION 235216

SECTION 237416.13 - PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes packaged, large-capacity, rooftop air conditioning units (RTUs) with the following components:
 - 1. Casings.
 - 2. Fans, drives, and motors.
 - 3. Rotary heat exchanger.
 - 4. Coils.
 - 5. Refrigerant circuit components.
 - 6. Air filtration.
 - 7. Gas furnaces.
 - 8. UV germicidal irradiation section.
 - 9. Sound-attenuator section.
 - 10. Dampers.
 - 11. Electrical power connections.
 - 12. Controls.
 - 13. Roof curbs.
 - 14. Accessories.

1.3 DEFINITIONS

- A. RTU: Rooftop unit. As used in this Section, this abbreviation means packaged, large-capacity, rooftop air-conditioning units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.4 ACTION SUBMITTALS

- A. Product Data: For each RTU.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.
 - 3. Include unit dimensions and weight.

4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 6. Include certified coil-performance ratings with system operating conditions indicated.
 7. Include filters with performance characteristics.
 8. Include gas furnaces with performance characteristics.
 9. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each packaged, large-capacity, rooftop air-conditioning units.
1. Include plans, elevations, sections, and mounting details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Delegated-Design Submittal: For RTU supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
1. Include design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
 3. Wind- and Seismic-Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

1.5 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For manufacturer's warranty.
- B. Product Certificates: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Section 230548 "Vibration and Seismic Controls for HVAC."
1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- C. Source quality-control reports.
- D. System startup reports.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 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. Filters: One set(s) of filters for each unit.
 - 2. Gaskets: One set(s) for each access door.
 - 3. Filters: One set(s) of filters for each unit.

1.8 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of outdoor, semi-custom, air-handling unit that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: 1 year(s) from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of RTUs and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE 15 Compliance: For refrigeration system safety.
- E. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

F. UL Compliance: Comply with UL 1995.

G. Wind-Restraint Performance:

1. Basic Wind Speed: 130 MPH per ASCE 7-10.
2. Building Classification Category: III.
3. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

H. Seismic Performance: RTUs shall withstand the effects of earthquake motions determined according to ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified".
2. Component Importance Factor: 1.0.

2.2 CAPACITIES AND CHARACTERISTICS

1. See M6.1.

2.3 MANUFACTURERS

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

1. AAON.
2. Daikin Applied.

2.4 UNIT CASINGS

A. General Fabrication Requirements for Casings: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.

B. Double-Wall Construction:

1. Outside Casing Wall: Galvanized steel, minimum 18 gauge thick with manufacturer's standard finish, with pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
2. Inside Casing Wall: G90-coated galvanized steel, 0.034 inch thick.
3. Floor Plate: G90 galvanized steel, minimum 18 gauge thick.
4. Casing Insulation:
 - a. Materials: Injected polyurethane foam insulation.
 - b. Casing Panel R-Value: Minimum 13.
 - c. Insulation Thickness: 2 inches.

- d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roof of unit.
- C. Airstream Surfaces: Surfaces in contact with airstream shall comply with requirements in ASHRAE 62.1.
- D. Static-Pressure Classifications:
 - 1. For Unit Sections Upstream of Fans: Minus 3-inch wg.
 - 2. For Unit Sections Downstream and Including Fans: 4-inch wg.
- E. Panels and Doors:
 - 1. Panels:
 - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - b. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - c. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - d. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components. Dimensions to be at least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
 - 2. 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. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components. Dimensions to be at least 18 inches (450 mm) wide by full height of unit casing up to a maximum height of 60 inches.
 - 3. Locations and Applications:
 - a. Fan Section: Doors.
 - b. Access Section: Doors.
 - c. Coil Section: Inspection and access panels.
 - d. Damper Section: Doors.
 - e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
 - f. Mixing Section: Doors.
- F. Condensate Drain Pans:
 - 1. Location: Each type of cooling coil.
 - 2. Construction:
 - a. Single-wall, galvanized-steel or noncorrosive polymer sheet.

3. Drain Connection:
 - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - b. Minimum Connection Size: NPS 1.
4. Slope: Minimum 0.125-in./ft. slope, to comply with ASHRAE 62.1, in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
5. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1.
6. Width: Entire width of water producing device.
7. Depth: A minimum of 2 inches deep.
8. Pan-Top Surface Coating for Galvanized-Steel Drain Pans: Asphaltic waterproofing compound.

2.5 FANS, DRIVES, AND MOTORS

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
- B. Supply-Air Fans: Centrifugal, rated according to AMCA 210; galvanized or painted steel; mounted on solid-steel shaft.
 1. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway.
 2. Shaft Bearings:
 - a. Heavy-duty, self-aligning, pillow-block type with an L-50 rated life of minimum 100,000 hours according to ABMA 9.
 3. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 4. Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; steel or aluminum hub swaged to backplate and fastened to shaft with setscrews.
 5. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
 6. Shaft Lubrication Lines: Extended to a location outside the casing.
 7. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inch-wide by 0.028-inch-thick, galvanized-steel sheet.

- a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
- C. Drives, Direct: Factory-mounted, direct drive.
- D. Drives, Belt: Factory-mounted, V-belt drive, with adjustable alignment and belt tensioning, and with 1.25 service factor based on fan motor.
 - 1. Pulleys: Cast iron or cast steel with split, tapered bushing, dynamically balanced at the factory.
 - 2. Belts: Oil resistant, non-sparking and nonstatic; in matched sets for multiple-belt drives.
 - 3. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.146-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.
- E. Condenser-Coil Fan: Variable-speed propeller, mounted on shaft of permanently lubricated ECM motors.
- F. Relief-Air Fan: Propeller, shaft mounted on permanently lubricated motor.
- G. Motors:
 - 1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 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. Enclosure Type: Open, drip-proof.
 - 4. Enclosure Materials: Cast iron.
 - 5. Motor Bearings.
 - 6. Efficiency: Premium efficient as defined in NEMA MG 1.
 - 7. 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.
 - 8. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.6 COILS

- A. General Requirements for Coils:
 - 1. Comply with AHRI 410.
 - 2. Fabricate coils 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. Supply-Air Refrigerant Coil:

1. Tubes: Copper.
2. Fins:
 - a. Material: Aluminum.
 - b. Fin Spacing: Maximum 12 fins per inch.
3. Fin and Tube Joints: Mechanical bond.
4. Headers: Seamless-copper headers with brazed connections.
5. Frames: Stainless steel.
6. Coatings: None.
7. Ratings: Designed, tested, and rated according to ASHRAE 33 and AHRI 410.
 - a. Working Pressure: Minimum 300 psig.

2.7 REFRIGERANT CIRCUIT COMPONENTS

- A. Number of Refrigerant Circuits: Two.
- B. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief.
- C. Refrigeration Specialties:
 1. Refrigerant: R-410A.
 2. Expansion valve with replaceable thermostatic element.
 3. Refrigerant filter/dryer.
 4. Manual-reset high-pressure safety switch.
 5. Automatic-reset low-pressure safety switch.
 6. Minimum off-time relay.
 7. Automatic-reset compressor motor thermal overload.
 8. Brass service valves installed in compressor suction and liquid lines.

2.8 AIR FILTRATION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. Panel Filters:
 1. Description: Pleated factory-fabricated, self-supported, disposable air filters with holding frames.
 2. Filter Unit Class: UL 900.
 3. Media: Interlaced glass, synthetic or cotton fibers coated with nonflammable adhesive and antimicrobial coating.
 4. Filter-Media Frame: Beverage board with perforated metal retainer, or metal grid, on outlet side.

2.9 GAS FURNACES

- A. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47/CSA 2.3 and NFPA 54.
- B. CSA Approval: Designed and certified by and bearing label of CSA.
- C. Burners: Stainless steel.
 - 1. Rated Minimum Turndown Ratio: 5 to 1.
 - 2. Fuel: Natural gas.
 - 3. Ignition: Electronically controlled electric spark or hot-surface igniter with flame sensor.
 - 4. Gas Control Valve: Modulating.
 - 5. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.
- D. Heat-Exchanger and Drain Pan: Stainless steel.
- E. Venting, Power: Power vented, with integral, motorized centrifugal fan interlocked with gas valve with vertical extension.
- F. Safety Controls:
 - 1. Gas Manifold: Safety switches and controls complying with ANSI standards.

2.10 DAMPERS

- A. Dampers: Comply with requirements in Section 230923.12 "Control Dampers."
- B. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg
- C. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."

2.11 ELECTRICAL POWER CONNECTIONS

- A. RTU shall have a single connection of power to unit with unit-mounted disconnect switch accessible from outside unit and control-circuit transformer with built-in overcurrent protection.

2.12 CONTROLS

- A. Basic Unit Controls:
 - 1. Control-voltage transformer.

2. Unit-Mounted Annunciator Panel for Each Unit:
 - a. Lights to indicate power on, cooling, heating, fan running, filter dirty, and unit alarm or failure.
 - b. DDC controller or programmable timer and interface with HVAC instrumentation and control system.
 - c. Digital display of outdoor-air temperature, supply-air temperature, return-air temperature, economizer damper position, indoor-air quality, and control parameters.
3. Comply with requirements as specified in 230923.

2.13 ROOF CURBS

- A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C1071, Type I or II.
 - b. Thickness: 2 inches.
 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C916, Type I.
- C. Curb Dimensions: Height of 24 inches minimum.

2.14 ACCESSORIES

- A. Electric heater with integral thermostat maintains minimum 50 deg F temperature in gas burner compartment.
- B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

- C. Return-air bypass damper.
- D. Factory- or field-installed demand-controlled ventilation.
- E. Safeties:
 - 1. Smoke detector.
 - 2. Condensate overflow switch.
 - 3. Phase-loss reversal protection.
 - 4. Highpressure control.
 - 5. Gas furnace airflow-proving switch.
- F. Coil guards of painted, galvanized-steel wire.
- G. Vertical vent extensions to increase the separation between the outdoor-air intake and the flue-gas outlet.
- H. Door switches to disable heating or reset set point when open.

2.15 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.
- D. Aluminum: ASTM B209.

2.16 SOURCE QUALITY CONTROL

- A. AHRI Compliance:
 - 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
 - 2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
 - 3. Comply with AHRI 1060 for testing and rating performance for air-to-air exchanger.
- B. AMCA Compliance:
 - 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
 - 2. Damper leakage tested in accordance with AMCA 500-D.

3. Operating Limits: Classify according to AMCA 99.

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Roof Curb: Install on roof structure or concrete base, level and secure, according to NRCA's "NRCA Roofing Manual: Membrane Roof Systems." Install RTUs on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure RTUs to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts. Coordinate sizes and locations of roof curbs with actual equipment provided.
- B. Equipment Mounting:
 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to RTU, allow space for service and maintenance.
- C. Connect piping to unit mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or roof drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Gas Piping: Comply with applicable requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.

- F. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

3.4 DUCT CONNECTIONS

- A. Comply with duct installation requirements specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination at top of roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Connect supply ducts to RTUs with flexible duct connectors specified in Section 233300 "Air Duct Accessories."
 - 4. Install return-air duct continuously through roof structure.

3.5 ELECTRICAL CONNECTIONS

- A. Connect electrical wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Locate nameplate where easily visible.

3.6 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.7 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
 - 1. Inspect for visible damage to unit casing.

2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Verify lubrication on fan and motor bearings.
14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
15. Adjust fan belts to proper alignment and tension.
16. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system.
 - b. Do not operate below recommended low-ambient temperature.
 - c. Complete startup sheets and attach copy with Contractor's startup report.
17. Inspect and record performance of interlocks and protective devices; verify sequences.
18. Operate unit for an initial period as recommended or required by manufacturer.
19. Perform the following operations for both minimum and maximum firing. Adjust burner for peak efficiency.
 - a. Measure gas pressure on manifold.
 - b. Inspect operation of power vents.
 - c. Measure combustion-air temperature at inlet to combustion chamber.
 - d. Measure flue-gas temperature at furnace discharge.
 - e. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - f. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
20. Calibrate thermostats.
21. Adjust and inspect high-temperature limits.
22. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
23. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outdoor-air, dry-bulb temperature.
 - d. Outdoor-air-coil, discharge-air, dry-bulb temperature.
24. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
25. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

- a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outdoor-air intake volume.
26. Simulate maximum cooling demand and inspect the following:
- a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.
27. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
- a. High-temperature limit on gas-fired heat exchanger.
 - b. Low-temperature safety operation.
 - c. Filter high-pressure differential alarm.
 - d. Economizer to minimum outdoor-air changeover.
 - e. Relief-air fan operation.
 - f. Smoke and firestat alarms.
28. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

3.8 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing RTUs and air-distribution systems and after completing startup service, clean RTUs internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 FIELD QUALITY CONTROL

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

- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. RTU will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

END OF SECTION 237416.13

SECTION 237423.16 - PACKAGED, INDIRECT-FIRED, OUTDOOR, MAKEUP-AIR UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes indirect-fired makeup-air units.

1.3 DEFINITIONS

- A. DDC: Direct digital control.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and configuration of outdoor, indirect-fired makeup-air unit.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Sustainable Design Submittals:
 - 1. Product Data: For ventilation equipment, indicating compliance with ASHRAE 62.1, Section 5 - "Systems and Equipment."
- C. Shop Drawings: For each type and configuration of outdoor, indirect-fired heating and ventilating unit.
 - 1. Signed, sealed, and prepared by or under the supervision of a qualified professional engineer.
 - 2. Include plans, elevations, sections, and attachment details.
 - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 4. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
 - 5. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 6. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

7. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Startup service reports.
- B. Sample Warranty: For manufacturer's special warranty.
- C. Seismic Qualification Certificates: For outdoor, indirect-fired makeup-air units, accessories, and components, from manufacturer.
 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For indirect-fired makeup-air units to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One sets for each unit.

1.8 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of indirect-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than 10 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. Accurex.
 2. CaptiveAire Systems.
 3. Greenheck Fan Corporation.
 4. Modine Manufacturing Company.

2.2 SYSTEM DESCRIPTION

- A. AHRI Compliance:
 1. Comply with AHRI 340/360 for testing and rating energy efficiencies for RTUs.
 2. Comply with AHRI 270 for testing and rating sound performance for RTUs.
- B. AMCA Compliance:
 1. Comply with AMCA 11 and bear the AMCA-Certified Ratings Seal for air and sound performance according to AMCA 211 and AMCA 311.
 2. Damper leakage tested in accordance with AMCA 500-D.
 3. Operating Limits: Classify according to AMCA 99.
- C. ASHRAE Compliance:
 1. Comply with ASHRAE 15 for refrigeration system safety.
 2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
 3. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. NFPA Compliance: Comply with NFPA 90A or NFPA 90B.
- F. UL Compliance: Comply with UL 1995.

2.3 UNIT CASINGS

- A. General Fabrication Requirements for Casings:

1. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 2. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 3. Factory Finish for Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.
 4. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
 - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling-unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC" when air-handling-unit frame is anchored to building structure.
 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Configuration: Horizontal unit with bottom discharge for roof-mounting installation.
- C. Cabinet: Galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Duct flanges at inlet and outlet. Pitched roof panels and knockouts with grommet seals for electrical and piping connections and lifting lugs.
- D. Outer Casing: 0.0598-inch-thick steel with heat-resistant, baked-enamel finish.
- E. Inner Casing:
1. Burner Section Inner Casing: 0.0299-inch-thick steel.
 2. Double-wall casing with inner wall of solid steel, for the following sections:
 - a. Blower section.
 - b. Filter section.
 - c. Mixing box.
 - d. Inlet plenum.
 - e. Discharge plenum.
 - f. Access Panels: Lift out for burner and fan motor assemblies on both sides of unit.
 3. Internal Insulation: Fibrous-glass duct lining, neoprene coated, comply with ASTM C 1071, Type II, applied on complete unit.
 - a. Thickness: 2 inches.
 - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
 - c. Density: 1.5 lb/cu. ft.
 - d. Mechanical Fasteners: Galvanized steel suitable for adhesive, mechanical, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
- F. Casing Insulation and Adhesive:

1. Materials: ASTM C 1071, Type I.
2. Location and Application: Encased between outside and inside casing.

G. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and 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.

H. Condensate Drain Pans:

1. Fabricated with two percent slope in at least two planes to collect condensate from condensate-producing heat exchangers and from humidifiers, 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. Formed sections.
3. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
5. Pan-Top Surface Coating: Asphaltic waterproofing compound.

2.4 ACCESSORIES

- A. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.
- B. Hail guards of galvanized steel, painted to match casing.

2.5 OUTDOOR-AIR INTAKE HOOD

- A. Type: Manufacturer's standard hood or louver.
- B. Materials: Match cabinet.
- C. Bird Screen: Comply with requirements in ASHRAE 62.1.
- D. Filter: Aluminum, 1 inch cleanable.
- E. Configuration: Designed to inhibit wind-driven rain and snow from entering unit.

2.6 ROOF CURBS

- A. Roof curbs with vibration isolators and wind or seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
 - 1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
 - a. Materials: ASTM C 1071, Type I or Type II.
 - b. Thickness: 1 inch.
 - 2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
 - a. Liner Adhesive: Comply with ASTM C 916, Type I.
 - b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
 - c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
 - d. Liner Adhesive: Comply with ASTM C 916, Type I.
- C. Curb Height: 14 inches.
- D. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match unit, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for wind-load requirements.

2.7 SUPPLY-AIR FAN

- A. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings. Bearing rating: L10 of 120,000 hours.
- B. Drive: Direct
- C. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, isolators.
- D. Fan-Shaft Lubrication Lines: Extended to a location outside the casing.

2.8 AIR FILTERS

- A. Comply with NFPA 90A.
- B. Disposable Panel Filters: Factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a MERV 8 filter.
 - 1. Thickness: 2 inches.
 - 2. Frame: Galvanized steel.
 - 3. Maximum Face Velocity: 500 fpm

2.9 DAMPERS

- A. Outdoor-Air and Return-Air Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of 4 cfm/sq. ft. of damper area, at a differential pressure of 2-inch wg.
- B. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.

2.10 INDIRECT-FIRED GAS BURNER

- A. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and with NFPA 54, "National Fuel Gas Code."
 - 1. CSA Approval: Designed and certified by and bearing label of CSA.
 - 2. Burners: Stainless steel.
 - a. Gas Control Valve: Modulating.
 - b. Fuel: Natural gas.
 - c. Minimum Combustion Efficiency: 80 percent.
 - d. Ignition: Electronically controlled electric spark with flame sensor.
- B. Venting: Power vented, with integral, motorized centrifugal fan interlocked with gas valve.

- C. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.
- D. Heat Exchanger: Stainless steel.
- E. Heat-Exchanger Drain Pan: Stainless steel.
- F. Safety Controls:
 - 1. Vent Flow Verification: Flame rollout switch.
 - 2. Control Transformer: 24-V ac.
 - 3. High Limit: Thermal switch or fuse to stop burner.
 - 4. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 - 5. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
 - 6. Gas Manifold: Safety switches and controls complying with ANSI standards and FM Global.
 - 7. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
 - 8. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
 - 9. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.

2.11 COILS

- A. Supply-Air Refrigerant Coil:
 - 1. Aluminum-plate fin and seamless copper tube in steel casing with equalizing-type vertical distributor.
 - 2. Polymer strip shall prevent all copper coil from contacting steel coil frame or condensate pan.
 - 3. Coil Split: Interlaced.

2.12 REFRIGERANT CIRCUIT COMPONENTS

- A. Compressor: Hermetic, variable speed scroll, mounted on vibration isolators; with internal overcurrent and high-temperature protection, internal pressure relief, and crankcase heater.
- B. Refrigeration Specialties:
 - 1. Refrigerant: R-410A.
 - 2. Expansion valve with replaceable thermostatic element.
 - 3. Refrigerant filter/dryer.
 - 4. Manual-reset high-pressure safety switch.
 - 5. Automatic-reset low-pressure safety switch.
 - 6. Minimum off-time relay.

7. Automatic-reset compressor motor thermal overload.
8. Brass service valves installed in compressor suction and liquid lines.

2.13 UNIT CONTROL PANEL

- A. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
- B. Control Panel: Surface-mounted remote panel, with engraved plastic cover and the following lights and switches:
 1. On-off-auto fan switch.
 2. Heat-vent-off switch.
 3. Supply-fan operation indicating light.
 4. Heating operation indicating light.
 5. Thermostat.
 6. Damper position potentiometer.
 7. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 8. Safety-lockout indicating light.
 9. Enclosure: NEMA 250, Type 3R.

2.14 CONTROLS

- A. Comply with requirements in Section 230923 "Direct Digital Control (DDC) System for HVAC."
- B. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
 1. Hardwired Points:
 - a. Room temperature.
 - b. Discharge-air temperature.
 - c. Burner operating.
 2. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC shall enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel shall be available through the DDC system for HVAC.

2.15 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.

2.16 CAPACITIES AND CHARACTERISTICS

- A. General: As indicated on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:
 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- B. Unit Support: Install heating and ventilating unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.
- C. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
- D. Install controls and equipment shipped by manufacturer for field installation with indirect-fired heating and ventilating units.
- E. Roof Curb: Install on roof structure or concrete base, level and secure, according to ARI Guideline B. Install units on curbs and coordinate roof penetrations and flashing with roof construction specified in Section 077200 "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.
- F. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

3.3 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
 - 1. Gas Piping: Comply with requirements in Section 231123 "Facility Natural-Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.
- B. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof or area drain.
- C. Duct Connections: Connect supply and return ducts to indirect-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
- C. Units will be considered defective if they 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.
- B. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
 - 1. Inspect for visible damage to burner combustion chamber.
 - 2. Inspect casing insulation for integrity, moisture content, and adhesion.
 - 3. Verify that clearances have been provided for servicing.
 - 4. Verify that controls are connected and operable.
 - 5. Verify that filters are installed.
 - 6. Purge gas line.
 - 7. Inspect and adjust vibration isolators and seismic restraints.

8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
10. Adjust fan belts to proper alignment and tension.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.
7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
11. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.6 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

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

END OF SECTION 237423.16

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes split-system air-conditioning and heat-pump units consisting of separate evaporator-fan and compressor-condenser components.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. 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. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set(s) for each air-handling unit.
2. Gaskets: One set(s) for each access door.

1.7 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."
- C. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1.

1.8 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 1. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts: One year(s) from date of Substantial Completion.
 - c. For Labor: One year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide product indicated on Drawings or comparable products by the following:
 1. Mitsubishi Electric & Electronics USA, Inc.
 2. Carrier
 3. Daikin.

- B. When basis of design manufacturer is not utilized, all necessary components, system design, hardware, piping, electrical components and connections, and miscellaneous accessories required by the alternate manufacturer shall be provided.

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Concealed Evaporator-Fan Components:

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
2. Insulation: Faced, glass-fiber duct liner.
3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
5. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
7. Air Filtration:
 - a. General Requirements:
 - 1) Comply with NFPA 90A.
 - 2) Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
 - 3) Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filter shall be removable from one side or lifted out from access plenum.
8. Condensate Drain Pans:
 - a. Fabricated with slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - b. Double-wall, galvanized stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.

- c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
- d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
- e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- f. Condensate Drain Pump: Required
- g. High Level Condensate Protection: Shut down unit on high condensate level
- h. Provide with CO2 monitoring in occupied spaces.

B. Wall-Mounted, Evaporator-Fan Components:

- 1. Cabinet: Enameled steel with removable panels on front and discharge drain pans with drain connection.
- 2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
- 3. Fan: Direct drive, centrifugal.
- 4. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Multitapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Enclosure Type: Totally enclosed, fan cooled.
 - d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
- 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- 6. Condensate Drain Pans:
 - a. Fabricated with slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
 - b. Double-wall, galvanized or stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - d. Pan-Top Surface Coating: Asphaltic waterproofing compound.
 - e. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
 - f. Condensate Drain Pump: Required.
 - g. High Level Condensate Protection: Shut down unit on high condensate level.
- 7. Air Filtration Section:

a. General Requirements for Air Filtration Section:

- 1) Comply with NFPA 90A.
- 2) Minimum MERV according to ASHRAE 52.2.
- 3) Filter-Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Refrigerant: R-410A.
 - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid subcooler. Comply with ARI 206/110.
3. Heat-Pump Components: Reversing valve and low-temperature-air cutoff thermostat.
4. Fan: Aluminum-propeller type, directly connected to motor.
5. Motor: Permanently lubricated, with integral thermal-overload protection.
6. Low Ambient Kit: Permits operation down to 20 deg F.
7. Mounting Base: Polyethylene.

2.4 ACCESSORIES

- A. Crankcase heater: Required.
- B. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
- C. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
- D. Filter-dryer: Required
- E. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
- F. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
- G. Sound Hood: Wraps around sound attenuation cover for compressor.

- H. Thermostatic expansion valve: Required.
- I. Reversing Valve: Required.
- J. Line Set Solenoid Valve: Required to provide total heat recovery.
- K. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
- L. Automatic-reset timer to prevent rapid cycling of compressor.
- M. Refrigerant Lines: In accordance with Division 23 Section "Refrigerant Piping."
- N. Drain Connection: Required.

2.5 CONTROLS:

- A. General: Provide controls by manufacturer to perform input functions necessary to operate the system.
- B. Wiring: Daisy chain configuration from indoor unit to indoor unit then to the outdoor unit. Control wiring shall run from the indoor unit terminal block the specific controller for that unit. Wiring shall be a shielded, AWG 18-2 in accordance with Division 26 requirements.
- C. Web Enabled Intelligent Controller
 - 1. General: Wall mounted, hard wired, ABS plastic with KCD display.
 - 2. Control: Capable of individually controlling the following functions at each indoor unit:
 - a. On/Off
 - b. Operating Mode
 - c. Set Point
 - d. Fan Speed
 - e. Timer Settings
 - f. Test Run.
 - 3. Display: Capable of displaying the following information for each indoor unit:
 - a. On/Off.
 - b. Operating Mode.
 - c. Set Point.
 - d. Fan Speed
 - e. Timer Settings
 - f. Test Run
 - g. Fault Diagnosis.
 - 4. Communications Adapter: RS485 connection, LCD display.
- D. Individual Zone Controller:

1. Self-Diagnosis Function: Required.
2. Display: LCD in 1°F increments.
3. Monitoring: Status, malfunction flashing, malfunction content, filter sign, operation mode, temperature setting, permit/prohibit selection, fans speed.
4. Scheduling: ON/OFF timer
5. Control Management: Field setting mode, group setting, auto re-start
6. Auxiliary Contact: External dry contact, 12 VDC relay.

E. Gateway:

1. BACnet compatible with monitoring only function made available to the EMCS.

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 roof-mounted, compressor-condenser components on equipment supports as indicated on drawings.
- D. Install seismic restraints.
- E. Equipment Mounting:
 1. Comply with requirements for vibration isolation and seismic control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.
- G. Install control wiring.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
- C. Duct Connections: Duct installation requirements are specified in Section 233113 "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 Section 233300 "Air Duct Accessories."

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- C. Tests and Inspections:
 - 1. 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.
- D. Remove and replace malfunctioning units and retest as specified above.
- E. Prepare test and inspection reports.

3.4 STARTUP SERVICE

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

3.5 DEMONSTRATION

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

3.6 COMMISSIONING

- A. Commissioning Authority
 - 1. The commissioning authority (CA) has been contracted directly with the owner for this project. The CA has overall responsibility for planning and coordinating the commissioning process. However, commissioning involves all parties involved with the design and construction process, including the mechanical contractor, and all specialty sub-contractors within Division 23, such as sheet metal, piping, refrigeration, water treatment, TAB and controls, plus major equipment suppliers as required.

END OF SECTION 238126

SECTION 238239.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes cabinet unit heaters with centrifugal fans and hot-water coils.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. DDC: Direct digital control.
- C. PTFE: Polytetrafluoroethylene plastic.
- D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include location and size of each field connection.
 - 4. Include details of anchorages and attachments to structure and to supported equipment.
 - 5. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 6. Indicate location and arrangement of piping valves and specialties.
 - 7. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Suspended ceiling components.
 2. Structural members to which cabinet unit heaters will be attached.
 3. Method of attaching hangers to building structure.
 4. Size and location of initial access modules for acoustical tile.
 5. Items penetrating finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Sprinklers.
 - d. Access panels.
 6. Perimeter moldings for exposed or partially exposed cabinets.
- B. Seismic Qualification Data: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC." Include the following:
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. Include detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. INDEECO.
 2. QMark; Marley Engineered Products.

2.2 DESCRIPTION

- A. Factory-assembled and -tested unit complying with AHRI 440.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Cabinet unit heaters 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."

2.4 CABINETS

- A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.
 - 1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch-thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
 - 2. Recessed Flanges: Steel, finished to match cabinet.
 - 3. Control Access Door: Key operated.
 - 4. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.

2.5 COILS

- A. 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.

2.6 CONTROLS

- A. 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 Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

- B. Control devices and operational sequences are specified in Section 230923 "Direct Digital Control (DDC) System for HVAC" and Section 230993.11 "Sequence of Operations for HVAC DDC."
- C. Basic Unit Controls:
 - 1. Control voltage transformer.
 - 2. Wall-mounted thermostat with the following features:
 - a. Heat-off switch.
 - b. Fan on-auto switch.
 - c. Manual fan-speed switch.
 - d. Adjustable deadband.
 - e. Exposed set point.
 - f. Exposed indication.
 - g. Deg F indication.
- D. Interface with DDC System for HVAC Requirements:
 - 1. Interface relay for scheduled operation.
 - 2. Interface relay to provide indication of fault at central workstation.
 - 3. Interface shall be BAC-net compatible for central DDC system for HVAC workstation and include the following functions:
 - a. Adjust set points.
 - b. Cabinet unit-heater start, stop, and operating status.
 - c. Data inquiry, including supply-air and room-air temperature.
 - d. Occupied and unoccupied schedules.
- E. Electrical Connection: Factory-wired motors and controls for a single field connection.

2.7 CAPACITIES AND CHARACTERISTICS

- 1. As specified on the drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."
- B. Install cabinet unit heaters to comply with NFPA 90A.
- C. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints. Vibration isolators and seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

3.3 CONNECTIONS

- A. Piping installation requirements are specified in Section 232113 "Hydronic Piping," Section 232116 "Hydronic Piping Specialties," " Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
- D. Comply with safety requirements in UL 1995.
- E. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of cabinet unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties."
- F. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- G. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.

- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature set points.

3.6 DEMONSTRATION

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

END OF SECTION 238239.13

SECTION 238239.19 - WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Include details of anchorages and attachments to structure and to supported equipment.
 - 4. Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories.
 - 5. Wiring Diagrams: Power, signal, and control wiring.
- C. Samples: For each exposed product and for each color and texture specified.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wall and ceiling unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. INDEECO.
 - 2. QMark; Marley Engineered Products.

2.2 DESCRIPTION

- A. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.3 CABINET

- A. Front Panel: Extruded-aluminum bar grille, with removable panels fastened with tamperproof fasteners.
- B. Finish: Baked enamel over baked-on primer with manufacturer's standard color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- D. Surface-Mounted Cabinet Enclosure: Steel with finish to match cabinet.

2.4 COIL

- A. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection. Provide integral circuit breaker for overcurrent protection.

2.5 FAN AND MOTOR

- A. Fan: Aluminum propeller directly connected to motor.
- B. Motor: Permanently lubricated. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.6 CONTROLS

- A. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit.
- B. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch.

2.7 CAPACITIES AND CHARACTERISTICS

- 1. As specified on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall and ceiling unit heaters to comply with NFPA 90A.
- B. Install wall and ceiling unit heaters level and plumb.
- C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

END OF SECTION 238239.19

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Alpha Wire.
 - 2. Belden Inc.
 - 3. Encore Wire Corporation.
 - 4. General Cable Technologies Corporation.
 - 5. Southwire Incorporated.
- B. Aluminum and Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.
- C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2, Type XHHW-2.
- D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC with ground wire.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Gardner Bender.
 - 3. Hubbell Power Systems, Inc.
 - 4. Ideal Industries, Inc.
 - 5. Ilsco; a branch of Bardes Corporation.
 - 6. NSi Industries LLC.
 - 7. O-Z/Gedney; a brand of the EGS Electrical Group.
 - 8. 3M; Electrical Markets Division.
- B. Description: Factory-fabricated spring connectors wire nuts and splices of size, ampacity rating, material, type, and class for application and service indicated.
- C. Quick push-in wire connectors are prohibited.

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.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper for feeders smaller than No. 4 AWG; aluminum for feeders No. 4 AWG and larger. All feeder conductors shall be copper up to 100Amps and copper or compact aluminum above 100Amps; aluminum conductors shall not be allowed for branch circuit wiring.
- B. Branch Circuits: Copper. Stranded.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
- B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.

- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-2-THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-2-THWN-2, single conductors in raceway, Metal-clad cable, Type MC. MC Cable shall not be used for multi-wire branch circuits, nor in any location in the kitchen environment. MC cable shall not be used in walls under the exterior windows or interior windows.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- H. Dedicated neutrals will be provided in multi-wire branch circuit runs.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- C. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."
- G. Provide an individual neutral conductor for each single hot (phase) wire. Do not share neutrals.
- H. Multiconductor cable: Rigid raceways must be used between panelboards and rooms, and must terminate in the ceiling space at a j-box. Multiconductor cable may only be used from this j-box to devices.

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Make splices, terminations, and taps that are compatible with conductor material.

- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes: Grounding systems and equipment.

1.3 ACTION SUBMITTALS

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

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.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Hydraulic compression tool applied connectors where possible, or exothermic-welding process recommended by kit manufacturer for materials being joined and installation conditions. Manufacturers: Burndy, Thomas & Betts, Cadweld.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel, 3/4 inch by 10 feet long, tapered point, chamfered top.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
- C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.

2. Underground Connections: Welded connectors except as otherwise indicated.
3. Connections to Ground Rods: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 1. Feeders and branch circuits.
 2. Lighting circuits.
 3. Receptacle circuits.
 4. Single-phase motor and appliance branch circuits.
 5. Three-phase motor and appliance branch circuits.
 6. Flexible raceway runs.
 7. PVC raceway runs.
 8. Rooftop raceway runs.
 9. 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.
 10. 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.
 11. Cable tray grounding.
 12. Communications rack grounding.
 13. Communications fittings.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- D. Water Heater: Install a separate insulated equipment grounding conductor to each electric water heater. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service unless otherwise indicated.
- F. 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 (6.3-by-100-by-300-mm) grounding bus.
3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

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: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.
 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- D. Grounding and Bonding for Piping:
 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. 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.

- F. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
 - 1. Section 260548.16 "Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- B. 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.

1.5 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.

- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
 - 1. Trapeze hangers. Include Product Data for components.
 - 2. Steel slotted channel systems. Include Product Data for components.
 - 3. Equipment supports.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

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. 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:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.
 - 4) MKT Fastening, LLC.
 2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 5. Toggle Bolts: All-steel springhead type.
 6. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT and RMC as required by NFPA 70 unless noted otherwise. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Conduits shall be supported within 18" of outlets, boxes, panels, cabinets. Maximum distance between supports is not to exceed 5'-0". Prevent movement and / or sag of junction boxes, pull boxes, or other conduit terminating housings located above suspended ceilings by suspending them from appropriate supports or roof structure.

- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts. To Light Steel: Sheet metal screws.
 6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting" for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Metal conduits, tubing, and fittings.
 - 2. Nonmetal conduits, tubing, and fittings.
 - 3. Metal wireways and auxiliary gutters.
 - 4. Surface raceways.
 - 5. Boxes, enclosures, and cabinets.
 - 6. Handholes and boxes for exterior underground cabling.

- B. Related Requirements:

- 1. Section 260543 "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
 - 2. Section 270528 "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
 - 3. Section 280528 "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.
- B. IMC: Intermediate metal conduit.
- C. EMT: Electrical metallic tubing.
- D. FMC: Flexible metal conduit.
- E. LFMC: Liquidtight flexible metallic conduit.
- F. PVC: Rigid Polyvinyl Chloride conduit.
- G. RNC: Rigid Nonmetallic conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, hinged-cover enclosures, and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AFC Cable Systems, Inc.
 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 3. O-Z/Gedney; a brand of EGS Electrical Group.
 4. Southwire Company.
 5. Thomas & Betts Corporation.
 6. Western Tube and Conduit Corporation.
- B. 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.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. IMC: Comply with ANSI C80.6 and UL 1242.
- E. EMT: Comply with ANSI C80.3 and UL 797.
- F. FMC: Comply with UL 1; zinc-coated steel.
- G. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew with insulated throat.
 2. 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.
- I. Joint Compound for IMC, 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 CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AFC Cable Systems, Inc.
 2. Anamet Electrical, Inc.
 3. Arnco Corporation.
 4. CANTEX Inc.
 5. CertainTeed Corp.
 6. Condux International, Inc.
 7. Electri-Flex Company.
 8. Kraloy.
 9. Lamson & Sessions; Carlon Electrical Products.
 10. Niedax-Kleinhuis USA, Inc.
 11. RACO; a Hubbell company.
 12. Thomas & Betts Corporation.
- B. 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.
- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Fittings for RNC: Comply with NEMA TC 3; match to conduit type and material.
- E. 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).

2.3 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cooper B-Line, Inc.
 2. Hoffman; a Pentair company.
 3. Square D; a brand of Schneider Electric.
- B. Description: Sheet metal, complying with NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.
1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Panduit Corp.
 - b. Thomas & Betts Corporation.
 - c. Wiremold / Legrand.

2.5 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. Hoffman; a Pentair company.
 - 4. Hubbell Incorporated; Killark Division.
 - 5. Mono-Systems, Inc.
 - 6. O-Z/Gedney; a brand of EGS Electrical Group.
 - 7. RACO; a Hubbell Company.
 - 8. Thomas & Betts Corporation.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.
- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb (23 kg). Outlet boxes designed for attachment of luminaires weighing more than 50 lb (23 kg) shall be listed and marked for the maximum allowable weight.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- I. Device Box Dimensions: 4 inches square by 1-1/2 inches deep.

- J. Signal System Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- K. Floor Boxes: Provide floor boxes locations per electrical and communications drawings. All floor boxes shall be code-approved metal construction, with gasketed metal covers, flush with floor grade (even in use). Manufacturers: Wiremold Omnibox Series or Hubbell with adjustable collars and frames, or approved by Beaverton School District Representative. Minimum floor box requirements: 3 7/16" deep with 1" factory knockouts
- L. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.

2.6 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.
 - 3. In-ground boxes shall have the load bearing capacity to support riding lawn mowers and similar ground-keeping equipment in all locations.
- 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. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Oldcastle Precast, Inc.; Christy Concrete Products.
 - f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
 - 2. Standard: Comply with SCTE 77.
 - 3. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 6. Cover Legend: Molded lettering, "ELECTRIC."
 - 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.

8. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Nordic Fiberglass, Inc.
 - f. Oldcastle Precast, Inc.; Christy Concrete Products.
 - g. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
 2. Standard: Comply with SCTE 77.
 3. Color of Frame and Cover: Gray.
 4. Configuration: Designed for flush burial with closed bottom unless otherwise indicated.
 5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 7. Cover Legend: Molded lettering, "ELECTRIC."
 8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 9. Handholes 12 Inches Wide by 24 Inches Long (300 mm Wide by 600 mm Long) and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: EMT.
 3. Underground Conduit: Type EPC-40-PVC, direct buried.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC, no more than 6 feet.
 5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed, Not Subject to Physical Damage: EMT.

2. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - c. Mechanical rooms.
 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations. Sealtite shall be used where flexible conduit connections are required and at connections to all motorized equipment and motors.
 5. Damp or Wet Locations: GRC.
 6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch (21-mm) trade size.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. EMT: Use setscrew, steel fittings with insulated throat. Comply with NEMA FB 2.10.
 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
 4. All heavy wall conduits shall have two locknuts and a bushing at each termination outlet box, junction box, except where terminated in a threaded hub.
- E. Install surface raceways only where indicated on Drawings. Use metallic raceway.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).
- G. Exposed low voltage cables are not allowed to be supported from electrical conduit system.
- H. Conduit bodies are allowed for feeders and branch circuits less than or equal to 100 amps and for signal cabling not related to data communications.

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.
- B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring and communications conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction. Conduit bends shall be made with appropriate tools of proper size; radius of bends shall be at least six times the diameter of the conduit.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated.
- H. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- I. Bushings and connectors shall be plastic insulated, lined, 105degC rated. A bushing shall be used where conduit enters a panelbox.
- J. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 5-foot intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Provisions shall be made to assure a minimum cover of 2" of concrete.
 - 4. All transitions from PVC underground to grade must have GRC 90 deg for all size raceways.
- K. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- M. Cut conduit perpendicular to the length. For conduits 2-inch (53-mm) trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- N. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- O. Surface Raceways:
 - 1. Install surface raceway with a minimum 2-inch (50-mm) radius control at bend points.
 - 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches (1200 mm) and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

- P. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where an underground service raceway enters a building or structure.
 2. Where otherwise required by NFPA 70.
- Q. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- R. Expansion-Joint Fittings:
1. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 2. 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.
 3. Fittings shall be type "AX" or "TX" as made by O-Z Electric Company, or equal. Provide copper bonding jumper at each expansion fitting.
- S. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches (1830 mm) of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC in damp or wet locations not subject to severe physical damage.
- T. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- U. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- V. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- W. Locate boxes so that cover or plate will not span different building finishes.
- X. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- Y. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- Z. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom for pipe less than 6 inches (150 mm) in nominal diameter.
2. Install backfill.
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 (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction.
4. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete for a minimum of 12 inches (300 mm) on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."
6. A minimum of 18" of cover ground shall be provided.
7. PVC conduit shall transition with 90 deg GRC bend where it emerges from the ground or concrete in all locations which it is installed.

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. Install handholes and boxes as required to avoid exceeding maximum allowed bends for raceways.
- C. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- D. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch (25 mm) above finished 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 Section 260544 "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 078413 "Penetration Firestopping."

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Conduit, ducts, and duct accessories for direct-buried duct banks, and in single duct runs.
 - 2. Handholes and boxes.

1.3 DEFINITION

- A. RNC: Rigid nonmetallic conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Duct-bank materials, including separators and miscellaneous components.
 - 2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
 - 3. Accessories for manholes, handholes, boxes.
 - 4. Warning tape.

1.5 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
- B. Store precast concrete underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
- C. Lift and support precast concrete units only at designated lifting or supporting points.

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 according to requirements indicated:
 - 1. Notify Owner no fewer than two 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 layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.
- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

PART 2 - PRODUCTS

2.1 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
- B. RNC: NEMA TC 2, Type EPC-40-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.2 PRECAST CONCRETE HANDHOLES AND BOXES

- 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. Carder Concrete Products.
 - 2. Christy Concrete Products.
 - 3. Elmhurst-Chicago Stone Co.
 - 4. Oldcastle Precast Group.
 - 5. Riverton Concrete Products; a division of Cretex Companies, Inc.
 - 6. Utility Concrete Products, LLC.
 - 7. Utility Vault Co.

8. Wausau Tile, Inc.
- C. Comply with ASTM C 858 for design and manufacturing processes.
- D. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
 1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 2. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 3. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
 4. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing bolts.
 - a. Cover Hinges: Concealed, with hold-open ratchet assembly.
 - b. Cover Handle: Recessed.
 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 6. Cover Legend: Molded lettering, "ELECTRIC" or "TELEPHONE" as indicated for each service.
 7. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
 8. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.3 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Description: Comply with SCTE 77.
 1. Color: Gray.
 2. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, "ELECTRIC" or "TELEPHONE" as indicated for each service.
 6. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
 7. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.
- B. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.
- C. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

3.2 EARTHWORK

- A. Excavation and Backfill: Do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Cut and patch existing pavement in the path of underground ducts and utility structures.

3.3 DUCT INSTALLATION

- A. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
- B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of 48 inches (1220 mm), both horizontally and vertically, at other locations, unless otherwise indicated.
- C. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- D. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least 10 feet (3 m) outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

- E. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15-psig (1.03-MPa) hydrostatic pressure.
- F. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.
- G. Direct-Buried Duct Banks:
 - 1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 - 2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 4 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.
 - 3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms for pipes less than 6 inches (150 mm) in nominal diameter.
 - 4. Install backfill.
 - 5. Install ducts with a minimum of 3 inches (75 mm) between ducts for like services and 6 inches (150 mm) between power and signal ducts.
 - 6. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
 - 7. Set elevation of bottom of duct bank below the frost line.
 - 8. 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 the length of the elbow.
 - 9. 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 (75 mm) of concrete.
 - b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.4 INSTALLATION OF HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and traffic ways, set so cover surface will be flush with finished grade.

3.5 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.6 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND
CABLING

PART 1 - GENERAL

1.1 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. Section 078413 "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. Wall Sleeves:

1. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

2.2 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, 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 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 (34.5-MPa), 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

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 Section 079200 "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 (6.4-mm) 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 (50 mm) 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 (25-mm) 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 (25-mm) 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 260544

SECTION 260548.16 - SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Channel support systems.
 - 2. Hanger rod stiffeners.
 - 3. Anchorage bushings and washers.
- B. Related Sections include the following:
 - 1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

- A. The IBC: International Building Code.

1.4 PERFORMANCE REQUIREMENTS

- A. Wind-Restraint Loading:
 - 1. Basic Wind Speed: 115 MPH.
 - 2. Building Classification Category: III.
 - 3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by maximum area of HVAC component projected on vertical plane normal to wind direction and 45 degrees either side of normal.
- B. Seismic-Restraint Loading:
 - 1. Site Class as Defined in the IBC: D.
 - 2. Assigned Seismic Use Group or Building Category as Defined in the IBC: III.
 - a. Component Importance Factor: 1.0.
 - b. Component Response Modification Factor: 1.5.
 - c. Component Amplification Factor: 1.0.
 - 3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 143% of 6.

4. Design Spectral Response Acceleration at 1.0-Second Period: 56% of 6.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details 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 static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.

1.6 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- 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. Ace Mountings Co., Inc.
 2. Amber/Booth Company, Inc.

3. California Dynamics Corporation.
 4. Isolation Technology, Inc.
 5. Kinetics Noise Control.
 6. Mason Industries.
 7. Vibration Eliminator Co., Inc.
 8. Vibration Isolation.
 9. Vibration Mountings & Controls, Inc.
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1. Resilient Material: Oil- and water-resistant neoprene.
- C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

- 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. Amber/Booth Company, Inc.
 2. California Dynamics Corporation.
 3. Cooper B-Line, Inc.; a division of Cooper Industries.
 4. Hilti Inc.
 5. Loos & Co.; Seismic Earthquake Division.
 6. Mason Industries.
 7. TOLCO Incorporated; a brand of NIBCO INC.
 8. Unistrut; Tyco International, Ltd.

- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES.
 - 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.
- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES.
- B. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.
- C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- #### A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

END OF SECTION 260548.16

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for conductors.
 - 2. Underground-line warning tape.
 - 3. Warning labels and signs.
 - 4. Equipment identification labels.
 - 5. Arc Flash label per NEC.

1.3 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Arc Flash Hazard Analysis.

1.4 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.5 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. Labeling is to be reviewed and approved by the Facilities Project Manager & Electrical Supervisor.
- C. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- D. Coordinate installation of identifying devices with location of access panels and doors.

- E. Install identifying devices before installing acoustical ceilings and similar concealment.
- F. Panels require labeling of necessary PPE with potential hazards as a result of Arc Flash Hazard Analysis. The Arc Flash Hazard Analysis shall be performed by the Electrical Contractor.

PART 2 - PRODUCTS

2.1 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

2.2 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Use insert polyethylene plastic ribbon, 6" wide by 4 mils thick. Install continuous tape, 6" to 8" below finish grade, for each exterior underground raceway. Provide trace wire with all underground conduits.
 - 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.
- 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, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.

2.3 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 (6.4-mm) grommets in corners for mounting.
 - 3. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Warning label and sign shall include, but are not limited to, the following:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2.4 EQUIPMENT IDENTIFICATION LABELS

- A. Normal Power Equipment: Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a black background. Minimum letter height shall be 3/8 inch (10 mm).
- B. Emergency Power Equipment: Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a red background. Minimum letter height shall be 3/8 inch (10 mm).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. If banks of switching are installed that control various systems (i.e. lighting, AV, and projection screen, etc.) or various spaces (i.e. classroom and corridor, etc.) labeling with 1/8" black letters indicating function of each switch is required.
- C. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

3.2 IDENTIFICATION SCHEDULE

- A. 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: White letters on a red background.
 2. Power: White letters on a black background.

- B. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral: White
 - 5) Ground: Green
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
 - 4) Neutral: Gray
 - 5) Ground: Green
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- C. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification. Install engraved label on the inside of flush panels, visible when the door is open.
1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine label, black with white core for normal power and red with white letters for emergency power. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 2. Equipment to Be Engraved Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer, with separate columns for odd and even numbers, using

final building room numbers and identifications. Panelboard identification shall be engraved, laminated acrylic or melamine label. Panelboard label shall identify panel, voltage, and electrical source. Each electrical panel ID should start with number where "2" will indicate 208/120V system and "4" will indicate 480/277V system.

- b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Switchboards.
 - e. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
 - f. Emergency system boxes and enclosures.
 - g. Enclosed switches.
 - h. Enclosed circuit breakers.
 - i. Enclosed controllers.
 - j. Variable-speed controllers.
 - k. Push-button stations.
 - l. Power transfer equipment.
 - m. Contactors.
 - n. Remote-controlled switches, dimmer modules, and control devices.
 - o. Battery-inverter units.
 - p. Battery racks.
 - q. Power-generating units.
 - r. Monitoring and control equipment.
 - s. UPS equipment.
- 3. On the cover of junction and pull boxes, use label, or legibly write with indelible ink, the panel number, circuit number and voltage for each box.
 - 4. On the back of wiring devices including power receptacles and switches, use label, or legibly write with indelible ink, the panel number, circuit number and voltage for each wiring device.
 - 5. Contractor to supply (2) laminated one-line diagrams showing disconnects with Record Drawings for posting in main electrical room and emergency room.

END OF SECTION 260553

SECTION 260800 – LIGHTING SYSTEMS COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes general requirements that apply to implementation of commissioning of electrical systems and components. It will assist operating staff training and familiarization with new systems. It will serve as a tool to reduce post-occupancy critical systems operational difficulty or failure. It will, also, be used to develop test protocol and record the associated test data to advance the building systems from a state of substantial completion to operation.
- B. All electrical systems in the project shall perform in accordance with the design intent and the Owner's operational needs.
- C. The Commissioning Process Overview, applying to the electrical systems and electrical commissioning team members, can be found in specifications section 019113, General Commissioning Requirements.
- D. Systems to be commissioned:
 - 1. Electrical systems and all integral equipment controls. All electrical systems shall be commissioned, including, but not limited to:
 - a. Lighting controls
 - b. Exterior lighting controls

1.2 RESPONSIBILITIES

- A. Overview: The responsibilities of the electrical commissioning team members in the commissioning process are summarized in specifications section 019113, General Commissioning Requirements.

1.3 SUBMITTALS

- A. Other Equipment and System Information.
 - 1. When not included with the standard submittals, the Trade Subcontractors shall provide to the Commissioning Provider requested shop drawings, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures and control drawings. In addition, the manufacturer installation and checkout materials that are shipped inside the equipment and the field checkout forms to be used by the factory or field technicians shall be submitted to the Commissioning Provider. This documentation may be required prior to the normal O&M manual submittals.

- B. All equipment and system documentation requested by the Commissioning Provider shall be included by the Trade Subcontractors later in the O&M manuals.
- C. The Trade Subcontractors shall submit startup forms and procedures.

1.4 QUALITY ASSURANCE

- A. Test Equipment:
 - 1. All standard testing equipment required for the Trade Subcontractors to perform installation, start-up and initial checkout and required functional testing shall be provided by the Trade Subcontractors.
 - 2. Special tools and instruments, only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents shall be provided.
 - 3. Instrumentation will be provided by the Subcontractor. Instruments used for measurements shall be accurate. Calibration histories for each instrument shall be available for examination. Calibration and maintenance of instruments shall be in accordance with the requirements of NEBB or AABC Standards.
 - 4. Application of instruments and accuracy of measurements shall be in accordance with NEBB or AABC Standards.
 - 5. Datalogging equipment required for testing equipment in support areas shall be provided and used by the Commissioning Provider.

1.5 COORDINATION

- A. Commissioning Team: The members of the commissioning team consist of the Commissioning Provider, the Owner/Owner Representative, the GC, the Architect and Design Engineers, the mechanical contractor, the electrical contractor, the plumbing contractor, the testing adjusting and balancing contractor, the controls contractor, any other installing subcontractors or suppliers of commissioned equipment or systems and the facility or plant operator/engineer.

PART 2 - PRODUCTS NOT USED

PART 3 - EXECUTION

3.1 MEETINGS

- A. Kick-off Meeting: The Commissioning Provider will schedule, plan and conduct a commissioning kick-off meeting with the entire commissioning team in attendance, including the controls, electrical, plumbing, mechanical, adjusting and balancing and other appropriate Trade Subcontractors and the facility operator or Owner Representative in attendance. Prior to this meeting, the commissioning plan will be distributed to all members. The commissioning plan, the overall commissioning process and general responsibilities of each team member,

reporting and communication protocols and next steps will be discussed. Meeting minutes will be distributed to all parties by the Commissioning Provider.

- B. Miscellaneous Meetings: Deficiencies identified through the commissioning process shall be discussed, as needed, in portions of regular construction meetings. Meetings dedicated to deficiencies or commissioning: status, coordination and planning shall also be conducted, if needed. The Commissioning Provider will plan, conduct and take minutes at commissioning meetings. When practical, commissioning meetings will be an appendage to regular construction meetings. All commissioning meetings shall be attended by the GC, the mechanical and the controls subcontractor. Selected meetings shall require the attendance of the electrical, plumbing, TAB or other trades of commissioned systems.
- C. Controls Integration Meeting: The Commissioning Provider coordinates the meeting to go over the control drawings, sequences of operation included in the controls submittal. This meeting is held prior to the approval of the controls submittal. The intent is to clarify control related issues for the controls contractor, mechanical, plumbing, and electrical contractor, facility staff and Commissioning Provider prior to startup, testing and balancing and functional testing.
 - 1. The controls contractor shall attend the meeting. The mechanical, electrical and general contractor shall attend when issues regarding equipment they are responsible for are discussed. The control technicians attending the meetings must be the same technicians that are/will install and program the DDC system.
 - 2. Primary issues discussed and clarified are:
 - a. Control drawing content
 - b. Point database (points (monitored points, software points, naming conventions, alarms, report format)
 - c. Sequences of operation and setpoints
 - d. Interlocks to packaged controls and other systems
 - e. Operator workstation graphics
 - f. Field sensor and panel locations
 - 3. The Commissioning Provider takes minutes at these meetings.

3.2 COMMISSIONING CHECKLISTS, START-UP, AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment and systems to be commissioned:
 - 1. Commissioning Checklists:
 - a. GC and Trade Subcontractors are to execute pre-functional system checks using the Commissioning Provider's created forms on the web based commissioning software Facility Grid.
 - b. The Commissioning Provider develops and completes the commissioning checklists and procedures for commissioned equipment and systems.
 - c. Calibrations: The construction checklists will contain requirements for calibrations when applicable. The Trade Subcontractors is responsible to calibrate all field-

installed sensors and actuators using checkout documentation methods approved by the Commissioning Provider.

2. Manufacturer Installation and Startup Procedures:

- a. A start-up plan shall be developed and submitted by the installing Subcontractor. Start-up plan to include the following:
 - 1) Manufacturer's tests.
 - 2) Lighting level verification
 - 3) Lighting room checkout and testing
 - 4) Exterior lighting checkout and testing
 - b. The Trade Subcontractors shall complete the pre-start procedures in the manufacturer startup forms prior to starting equipment. Startup shall be conducted under supervision of responsible manufacturer representatives for major pieces of equipment. The GC shall notify the Commissioning Provider at least 5 days in advance of any equipment start-up, providing the Commissioning Provider a copy of the start-up plan at that time.
 - c. The Commissioning Provider shall observe startup and checkout of selected systems.
 - d. The Trade Subcontractors and manufacturer representatives shall execute start-up and provide the Commissioning Provider with a signed and dated copy of the completed start-up documentation. The Trade Subcontractors shall clearly note any items that have not been completed and the plan for their completion.
 - e. The Trade Subcontractors shall operate each commissioned device or system to the full extent of its capability, from minimum to maximum, under automatic and manual control and verify that the equipment, system and assembly is functioning according to the specifications, manufacturer recommendations and good operating practice.
 - f. The Commissioning Provider will review startup documentation and identify incomplete areas.
 - g. The Trade Subcontractors shall correct all areas that are deficient or incomplete in the startup documentation in a timely manner.
3. Designated systems requiring test and balance work shall have this activity commence after systems have successfully completed start-up. System and equipment deficiencies observed during this activity is to be noted and corrected.

3.3 FUNCTIONAL TESTING

- A. Functional Performance Testing begins after operational testing and adjusting of the systems have been completed by the Subcontractors. Functional tests for a given system shall not be conducted until they are fully operational under normal and reliable control with control calibrations, programming complete and checked out and the Trade Subcontractors have submitted completed, applicable startup reports, satisfactory to the Commissioning Provider.

- B. The objective of the Functional Performance Testing is to advance the building systems from a state of substantial completion to full dynamic operation in accordance with the specified design requirements and design intent.
- C. Any test equipment, etc., needed to accomplish the functional performance tests shall be provided by Subcontractors.
- D. Subcontractors shall provide to the Commissioning Team documentation of calibration of controls. Documentation shall be dated and initialed by field engineer or technician performing the work.

3.4 DEFICIENCIES AND NON_CONFORMANCE

A. Deficiency Management

- 1. The Commissioning Provider will record the results of document reviews, field observations, tests conducted or reviewed and trend logs or monitoring. All deficiencies will be recorded on a Deficiency Log kept by the Commissioning Provider. The Deficiency Log will be kept updated by the Commissioning Provider.
- 2. A current copy of the Deficiency Log will be provided to the GC and Owner/Owner Representative on a regular basis, as requested. New deficiencies will be identified.
- 3. Items that are incomplete or are requiring Designer input will be sent to the Designer and Owner/Owner Representative by the Commissioning Provider via appropriate channels.
- 4. When completion of a deficiency has been identified by the Commissioning Provider as holding up or is likely to delay any commissioning process, particularly functional testing, the GC, shall be required to notify the Commissioning Provider providing the planned actions and an expected date of completion. The GC shall notify the Commissioning Provider listing the actions taken to resolve the issue. It is not the responsibility of the Commissioning Provider to obtain this status information through meeting attendance, asking questions or field observation.
- 5. The Commissioning Provider documents resolutions in the Deficiency Log and schedules retesting and backchecking as needed.
- 6. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the Commissioning Provider will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so.
 - a. The time for the Commissioning Provider to direct, document and evaluate any retesting required because a specific construction checklist or start-up test item, reported to have been successfully completed, but determined during testing to be faulty, will be charged to the GC.
 - b. The GC shall reimburse the Commissioning Provider for costs when a scheduled test cannot be completed due to:
 - 1) Failure of the GC to schedule the test with all parties required to perform the test or with regulatory authorities required to witness the test.
 - 2) Failure of the GC to provide required notice for tests that have been cancelled or rescheduled.

- 3) Failure of the GC or Trade Subcontractors to have in place test equipment, support equipment, instrumentation, permits, or other ancillary equipment or systems required for successful execution of the test.
 - 4) Failure of the Trade Subcontractors to complete pre-start or start-up procedures or other work required as a prerequisite for execution of the test.
7. The GC shall respond in writing to the Commissioning Provider at least as often as commissioning meetings are being scheduled concerning the status of each outstanding deficiency identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
- B. Approval and Acceptance: The Commissioning Provider will note each satisfactorily demonstrated function on the test form. Functional testing or acceptance of a system is indicated after all testing and monitoring is complete and there are no outstanding deficiencies for that equipment or system in the Commissioning Provider's Deficiency Log.

3.5 DEFERRED TESTING

- A. Unforeseen Deferred Tests: If any functional test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of functional testing may be delayed.

3.6 ADDITIONAL DOCUMENTATION

- A. Documentation required of the Trade Subcontractors shall consist of the following:
 1. Startup and initial checkout forms completed.
 2. Record of deficiencies and incomplete items for tests they are responsible to document.
 3. Training record.
- B. O&M Documentation Completion and Review:
 1. Prior to substantial completion, the Commissioning Provider shall review the O&M manuals for systems that were commissioned to verify compliance with the specifications. The Commissioning Provider will communicate deficiencies in the manuals to the Commissioning Team.
 2. The Commissioning Provider will also review each equipment warranty and verify that requirements to keep the warranty valid are clearly stated.
 3. This work does not supersede the Design Team's review of the O&M manuals.

3.7 TRAINING OF FACILITY PERSONNEL

- A. The Trade Subcontractors are responsible to provide training for facility personnel per the Contract Documents. The Trade Subcontractors shall work with the Commissioning Provider to develop appropriate training and orientation agendas for equipment and systems and provide skilled trainers for the sessions. The Commissioning Provider will verify that the Trade Subcontractors execute training per the Contract Documents.

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END OF SECTION 260800

SECTION 260913 – ELECTRICAL POWER MONITORING AND CONTROL

PART 1 - GENERAL

1.1 SCOPE

- A. This section defines the low voltage embedded sub-metering for use in the AC electrical equipment as outlined in the one-line and/or riser drawings. These solutions will provide a low voltage metering system integrated into the electrical equipment. The multi-circuit energy sub-meter solution shall offer an efficient system for commercial, sub-metering. The metering system shall provide the ability to report the energy information remotely using a web based software platform. The system must be expandable to accept non-electrical meter input for water and gas.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Section 262413 – Switchboard

1.3 SUBMITTALS

- A. Submit shop drawings and product data for approval and final documentation in the quantities listed according to the Conditions of the Contract. Customer name, customer location and customer order number shall identify all transmittals.
- B. Final Documents: Record documentation to include but not limited to: as-built wiring diagrams, meter/breaker/load schedule, factory test results and certificate(s), system commission report, manufacturers contact information, operation and installation manuals.

1.4 RELATED STANDARDS AND COMPLIANCE

- A. Meet the following recognized standards and approvals for applications:
 - 1. Accuracy:
 - a. ANSI C12.1
 - b. ANSI C12.20/0.2
 - 2. Safety/Construction

- a. CSA C22.2 No. 1010-1 Safety Requirements for Electrical Equipment for
 - b. Measurement
 - c. UL916 Energy Management Equipment
 - d. UL61010-1 (IEC 61010-1) Test and Measurement Equipment
3. Electro Magnetic Compatibility
- a. IEC 61000-4-2 Electrostatic Discharge (B)
 - b. IEC 61000-4-3 Radiated Immunity (A)
 - c. IEC 61000-4-4 Electric Fast Transient (B)
 - d. IEC 61000-4-5 Surge Immunity (B)
 - e. IEC 61000-4-6 Conducted Immunity
 - f. FCC Part 15 subpart B, Class A Digital Device, Radiated Emissions

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of this equipment shall have a minimum of 5 years' experience producing electronic submetering system equipment.
- B. Manufacturer shall provide embedded metering solutions.
- C. Manufacturer shall offer both a 1% and 0.2% accuracy solution.
- D. Comply with requirements of latest revisions of applicable industry standards.
- E. Manufacturer shall have remote web based tenant billing software solutions.
- F. Metering hardware shall be designed, factory installed and tested before shipping to site.
- G. Embedded solution must be a standard product offering by the panel manufacturer. Custom "one off" installed metering solutions are not acceptable.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Store and handle in strict compliance with manufacturer's instructions and recommendations. Protect from potential damage from weather and construction operations. If the meters are installed in equipment, store the equipment so condensation will not form on or in it. If necessary, apply temporary heat where required to obtain suitable service conditions.

PART 2 - PRODUCTS

2.1 HARDWARE OVERVIEW

- A. Current Transformers (CTs) - Manufacturer shall offer solid core designs and be rated for at least the following maximum amperage ratings; 50, 125, 250, 400, 600, 800 and 1200 amps. Solid core CTs shall meet Accuracy standard IEC 60044-1, Class 0.2s

1. CT's shall only have milliamp (100mA) output and measure accurately down to 1% of the maximum range.
2. CT's shall be self-protecting and not require shorting blocks.
3. CT's shall support 1.3 times CT rating.
4. CT's shall be rated for (CAT IV UL metering)
5. CT's shall be rated for 600VAC.

B. SENTRON PAC4200 multifunction power meter.

1. Provide a high accuracy power meter meeting the requirements set forth in this specification. Note any exceptions taken with a detailed description.
2. The meter shall have at least the following features:
 - a. Current inputs: The meter shall accept three 5A nominal current inputs. The current inputs are capable of measuring up to 5A RMS (300V RMS maximum voltage). All current inputs provide:
 - 1) Dielectric withstand of 3000Vrms 47-63 Hz for 1 minute.
 - 2) Surge protection of 120 A RMS for 1 second, non-recurring.
 - b. The meter shall have three voltage inputs (V1, V2, and V3). The voltage inputs can measure from 0 to 400 Vrms (line-to-neutral) or from 0 to 690 Vrms (line-to-line).
 - c. The meter shall have provisions for direct connection (require no PTs) for Wye (Star) systems up to 400 VAC (line-to-neutral) or 690 VAC (line-to-line). All voltage inputs provide:
 - 1) Dielectric withstand of 3250 VAC RMS, 60 Hz for 1 minute.
 - 2) Overload protection of 1500 VAC RMS continuous.
 - d. Standard Communications port shall be a RJ45 Modbus TCP 10/100BaseT Copper Ethernet communication.
 - e. The meter shall provide as "standard" the following Inputs/Outputs:
 - 1) Two Dry Digital Input – rated at 24 VDC / 0.7mA
 - 2) Two Dry Digital Output – rated 12-24 VDC, 0-10mA
 - f. A universal counter shall be designed into the meter to count pulses coming into the digital inputs for measuring variables such as Water, Gas, Air, etc.
 - g. Sample Rate shall be at least 170 samples / cycle.
 - h. Meter shall support multiple languages including English, German, French, Spanish, Italian, Portuguese, Turkish, Chinese and Russian.
 - i. Meter design shall be:
 - 1) A background-illuminated graphic LCD sized 128 x 96 pixel resolution.
 - 2) An overview size of 3.78"L x 3.78"W (96 x 96mm) and a depth of 2.00" (51mm), with an optional module added the depth shall be 2.87" (73mm).
 - j. Basic meter design shall provide for (2) two expansion slots.

- C. Micro Meter Modules – Individual micro metering modules shall be provided, one for each phase of the metered circuit. These meter modules will tie to the milliamp CT's. The CT's must be supplied by the manufacturer of the Meter Modules.
1. Meter modules shall measure data at 1% accuracy as tested in accordance with ANSI C12.20
 2. When grouped together, the Meter Modules shall allow for measurement of 1, 2 and 3 phase circuits.
 3. Meter Modules shall incorporate a dip switch selector to select phase A, B, or C, and have a LED indicator to indicate the phase.
 4. The Meter Module shall be able to accept inputs from all available milliamp CTs ranging from 50 to 1200A.
 5. Setup for the CT sizing on each Meter Module shall be done through the controller web page.
 6. Meter modules shall plug directly into the metering rack without any additional installation work or tools needed.
 7. All embedded metering solutions shall have the metering modules installed at the electrical equipment manufactures factory. No field installation shall be required.
 8. Meter modules shall be pre-calibrated and will never need future calibration.
 9. Meter modules shall provide a LED indicator to indicate if the unit has power and is communicating.
- D. Controller – The controller shall function as the collection, processing and setup point for the Micro metering units with a built-in web page interface.
1. Built-in Web page configuration and real-time data screens will include:
 - a. System settings: CT Ratios, PT Ratios, System type, Alarm Settings, communications settings and passwords
 - b. Global settings: for threshold and set-point alarms.
 - c. Real-Time data monitoring.
 - d. Diagnostics data to be used to monitor Modbus register address information being passed to other monitoring or control systems.
 - e. No third-party software shall be required to configure the Controller or Micro Metering modules.
 2. The Controller shall communicate metered values to BAS by:
 - a. BACnet
 - b. Modbus RTU or Modbus TCP.
 3. The Controller shall have one configurable (KY or KYZ) digital pulse output that can be used to output total Kwh data from one or more Micro Metering modules totalized together.
 4. The Controller shall be powered from its own voltage inputs and rated suitable for 480V, 240V, 208V and 120V AC applications.
- E. Service Types
1. Poly- Phase Four Wire

- F. Metering Data – Data recorded and calculated that can be passed on to an external system or displayed on the Controllers web page shall include for each breaker:
1. Energy: The meters shall provide true RMS, fully bi-directional and either 4-quadrant, revenue accurate or revenue certified energy metering for the following parameters.
 - a. kWh (Active Energy)
 - b. kVarh (Reactive Energy)
 - c. KVAh (Apparent Energy)
 - d. kW Demand
 - e. Integration of any instantaneous measurement
 2. Instantaneous: The meters shall provide high accuracy, 1 second, ½ cycle measurements, including true RMS per phase and total for the following parameters.
 - a. Voltage and current
 - b. Active, Reactive, and Apparent power (kW, kVAR, kVA)
 - c. Phase Angle
 - d. Power Factor
 - e. Current Demand
 - f. kW Demand
 3. Instantaneous Max: The meters shall record each new maximum value for the following parameters:
 - a. Current Demand
 - b. Current
 - c. kW Demand
 - d. kW
 4. Alarming/Monitoring: The system shall display and configure alarming for the following parameters
 - a. Phase Loss
 - b. Over Current Warning
 - c. Over Current Alarm
 - d. Over kW Demand Alarm
 - e. Under/Over Voltage Alarm

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The Contractor shall furnish, install and terminate all communication conductors and associated conduits external to any factory supplied equipment.
- B. All communications conductor wiring and routing shall be per the manufacturer's recommendations and as shown on the contract drawings.

- C. Additional connections to metering systems, where applicable, shall be done in the field by the manufacturer's start-up service group the installing contractor.

3.2 ADJUSTING AND CLEANING

- A. The meters and CT's shall be pre-calibrated and require only basic setup via the embedded web pages.
- B. Clean exposed surfaces using manufacturer recommended materials and methods.

3.3 TESTING

- A. Perform factory and installation tests in accordance with applicable NEC, NEMA, UL, ANSI, Weights and Measures California requirements.

3.4 WARRANTY

- A. Equipment manufacturer warrants that all goods supplied are free of non-conformities in workmanship and materials for one year from date of initial operation, but not more than eighteen months from date of shipment.

3.5 STARTUP SERVICES

- A. Engage a factory-authorized service representative to perform startup service of the metering system. The representative shall be trained and qualified for metering systems.
- B. Provide a qualified tradesman to assist in the commissioning of system.
- C. Obtain and submit as part of final documents a field commissioning report.
- D. Verify that the meters are installed and connected according to the Contract Documents.
- E. Complete installation and startup checks according to manufacturer's written instructions.

3.6 SUPPORT

- A. The electrical equipment manufacturer shall provide a 1-800 number for telephone support.
- B. The vendor shall provide training at a dedicated training facility, complete with software, devices and demonstrations or offer remote training services if required.
- C. The vendor shall also provide on-line support for technical information and literature.

END OF SECTION 260913

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching controls.
4. Indoor occupancy sensors.
5. Outdoor motion sensors.
6. Lighting contactors.
7. Emergency shunt relays.

- B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, and manual light switches.

1.3 PRE-SUBMITTAL MEETING

- A. A Representative for the company of the lighting controls to be installed shall have a pre-submittal meeting with the Electrical Engineer to discuss the design intent as shown on the construction documents and how it may be affected by system specific requirements, including but not limited to device locations and types, wiring diagrams, and system commissioning requirements.

1.4 ACTION SUBMITTALS

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

- B. Shop Drawings: Show installation details for occupancy and light-level sensors.

1. Interconnection diagrams showing field-installed wiring.
2. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROL UNITS

- A. Basis-of-Design Product: Provide Wattstopper DLM, no substitutions.
- B. System Description: Stand alone, multi zone lighting control interface to provide control coordination between all classroom (or similar spaces) lighting controls. The system shall provide coordination for the following controls.
 - 1. Occupancy Sensors: The classroom occupancy sensors shall connect to control unit. Classroom lighting shall be switched by control unit based on occupancy sensor signals.
 - 2. Photocells: Control unit shall interface with photocell in each classroom to dim lighting automatically with significant daylight. Control unit must have a minimum dimming time delay of 30 seconds to avoid changing state during passing clouds or other brief sun obstruction events. During times of peak sunlight, lights shall dim to minimum state instead of switching off to avoid classroom distractions caused by automatic switching.
 - 3. Wall Dimmers: Manual wall dimmers shall connect to control unit to provide dimming override of lighting, not allowing light levels to exceed automatic daylight dimmed levels.
 - 4. Lighting Fixtures: Control unit shall provide dimming control of 0-10V dimming drivers for LED fixtures.
 - 5. Network wiring: All Lighting Control Units shall be capable of providing status and trending data back to centralized PC via wired or wireless connection. Network front end and PC interconnectivity shall be FCIC. PC shall be FOIC. Software compatible with Lighting Control Unit shall be provided and installed on PC.
- C. System programming is done with hand-held remote-control tool, iphone application, or central computer system.
- D. Commissioning: Upon completion of installation, a factory representative shall come to the site to provide final programming and owner training for all classroom lighting control units.
- E. Wall-Switch Dimmer Tag S_{LVD} :
 - 1. Basis of design: Wattstopper LMDM-101.
 - 2. Voltage: 24V from DLM Network.

3. Display: LED bar graph for relative light level.
4. Program to single touch raise to full/dim to off; hold for raise and lower.

F. Wall-Switch Dimmer Tag S₅:

1. Basis of design: Wattstopper LMSW-105.
2. Voltage: 24V from DLM Network
3. Display: LED status indicator
4. Program scene buttons to control different scenes or loads; turn lights on or off with the paddle.

2.2 DAYLIGHT-HARVESTING SWITCHING CONTROLS

- A. Basis-of-Design Product: Provide photocell compatible with Lighting Control Unit Described in section 2.1 of this article.
- B. Ceiling-Mounted Switching Controls: Solid-state, light-level sensor unit, to detect changes in indoor lighting levels that are perceived by the eye.
- C. Electrical Components, Devices, and Accessories:
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
 3. Sensor Output: Low voltage digital or analog signal compatible Lighting Control Unit. Sensor is powered by Lighting Control Unit.
 4. General Space Sensors Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lux), with an adjustment for turn-on and turn-off levels within that range.
 5. Atrium Space Sensors Light-Level Monitoring Range: 100 to 1000 fc (1080 to 10 800 lux), with an adjustment for turn-on and turn-off levels within that range.
 6. Skylight Sensors Light-Level Monitoring Range: 1000 to 10,000 fc (10 800 to 108 000 lux), with an adjustment for turn-on and turn-off levels within that range.
 7. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling.
 8. Set-Point Adjustment: Equip with deadband adjustment of 25, 50, and 75 percent above the "on" set point, or provide with separate adjustable "on" and "off" set points.
 9. Test Mode: User selectable, overriding programmed time delay to allow settings check.
 10. Control Load Status: User selectable to confirm that load wiring is correct.

2.3 DAYLIGHT-HARVESTING DIMMING CONTROLS

- A. Basis-of-Design Product: Provide photocell compatible with Lighting Control Unit Described in section 2.1 of this article.
- B. System Description: Sensing daylight and electrical lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
 1. Lighting control set point is based on two lighting conditions:

- a. When no daylight is present (target level).
 - b. When significant daylight is present.
- C. Ceiling-Mounted Dimming Controls Tag P_D: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.
 1. Basis of design: Wattstopper LMLS-500.
 2. Voltage: 24V from DLM Network.
 3. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 4. Sensor Output: Low voltage digital signal compatible with Lighting Control Unit. Sensor is powered by Lighting Control Unit.
 5. Light-Level Sensor Set-Point Adjustment Range: 20 to 60 fc (120 to 640 lux).

2.4 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Provide Wattstopper, no substitutions.
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operation:
 - a. Common Spaces: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable, set to 15 minutes.
 - b. Classrooms: Unless otherwise indicated, configure for vacancy sensing. Lights are to be turned on manually, and the occupancy sensor will turn them off when unoccupied; with a time delay for turning lights off, adjustable, set to 15 minutes.
 3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 4. Power Pack (where required): 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. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 5. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 7. Bypass Switch: Override the "on" function in case of sensor failure.

8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.
- C. Ceiling Sensor Tag OS_D:
1. Basis of design: Wattstopper LMDC-100.
 2. Standard Range: 360-degree field of view with a minimum coverage area of 900 sq. ft. (84 sq. m).
 3. Sensing Technology: Dual technology - PIR and ultrasonic.
 4. Voltage: 24V from DLM Network.
 5. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 6. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 7. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
- D. PIR Type: Ceiling mounted; detect occupants in coverage area by their heat and movement.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.
- E. Ultrasonic Type: Ceiling mounted; detect occupants in coverage area through pattern changes of reflected ultrasonic energy.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).
- F. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm)

in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.5 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- A. Manufacturers: Provide Wattstopper, no substitutions.
- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor, suitable for mounting in a single gang switchbox.
 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
 3. Switch Rating: Not less than 800-VA fluorescent at 120 V, 1200-VA fluorescent at 277 V, and 800-W incandescent.
- C. Wall-Switch Sensor Tag S_{OS}:
 1. Basis of design: Wattstopper DW-100.
 2. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
 3. Sensing Technology: Dual technology - PIR and ultrasonic.
 4. Switch Type: SP.
 5. Voltage: 120 V; dual-technology type.
 6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
- D. Wall-Switch Sensor Tag S_{OS-LVD}:
 1. Basis of design: Watt Stopper.
 2. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
 3. Sensing Technology: Dual technology - PIR and ultrasonic.
 4. Switch Type: SP-1 button.
 5. Voltage: 24V from DLM Network.
 6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
 8. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.

2.6 EMERGENCY SHUNT RELAY

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Watt Stopper.
- 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 or 277 V.

2.7 HIGH-BAY OCCUPANCY SENSORS

- A. Tag OS_{PC}
- B. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbell Building Automation HBA WASP # FHB240 or comparable product by one of the following:
 - 1. Watt Stopper.
- C. General Description: Solid-state unit. The unit is designed to operate with the lamp and ballasts indicated.
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Operation: Turn lights on when coverage area is occupied, and off when unoccupied; with a time delay for turning lights off that is adjustable, set to 15 minutes.
 - 3. Operating Ambient Conditions: 32 to 149 deg F (0 to 65 deg C).
 - 4. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 - 5. Detector Technology: PIR.

2.8 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 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."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 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 (13 mm).
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non power-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.4 COMMISSIONING

- A. The lighting controls shall be programmed to behave as follows:
 - 1. Classrooms: The classroom contains four dimming zones 'a', 'b', 'c1' and 'c2' are controlled via a wall/dimmer switch by classroom entry and also a 5-button scene control by the teacher's station. Zones 'a' and 'c1' are in daylight zone. Zones 'b' and 'c2' are in general lighting zone. Zones 'c1' and 'c2' can be controlled together separately from zones 'a' and 'b' for presentation or whiteboard mode. Daylight zones shall dim in response to the photocell to maintain 40 footcandles measures at the students desk level. The occupancy sensors shall turn lights off automatically (manual-on/auto-off). When the rooms are un-occupied for 10 min lights cycle off. When the building arms, classroom lights cycle off.
 - 2. Project Spaces: Once the building is disarmed lights operate on occupancy sensors and photo cells and manual dimmers/switches. Lights can be overridden by a dimming switch by the door. Occupancy sensor can be programmed as vacancy sensor so lights are turned ON manually by teacher instead of occupancy sensor. When the rooms are un-occupied for 10 min lights cycle off. When the building arms, classroom lights cycle off.

3. Corridors: Once the building is disarmed lights operate on occupancy sensors. Photocells shall control lighting in the space to maintain 20 footcandles. Lighting is controlled by Occupancy Sensors. Lights are 25% when spaces are unoccupied, 100% when spaces are occupied. Also key switches in corridors can override the occupancy sensors. Once the building is armed lights cycle off after 10mins.
4. Restrooms: Lights operate on occupancy sensors. Lights can be over ridden by keyswitch. When the rooms are un-occupied 10 mins for Unisex and 15 min multiple user restrooms) the lights cycle off. When the building arms, lights cycle off.
5. Small offices: Once the building is disarmed lights operate on occupancy sensors and photo cells and manual dimmers/switches. Once occupancy is detected occupancy sensor in the room will turn on lights. However, they can be overridden by the user. The user has the ability to turn lights on/off and dim them up and down at button station near the door. Occupancy sensor can be programmed as vacancy sensor so lights are turned ON manually by teacher instead of occupancy sensor. When the rooms are un-occupied for 20 min lights cycle off. When the building arms, lights cycle off.
6. Commons: Once the building is disarmed lights operate on occupancy sensors and photo cells. There are (2) 4 scene buttons and rocker near double door to SpEd that can override to these scenes and one on opposite wall.
 1. All on/off
 2. Presentation, d off all others to 25%
 3. All off, b 25%
 4. Only a and c onR. All dim
When the rooms are un-occupied for 10 min lights cycle off. When the building arms, lights cycle off.
7. Kitchen: Once the building is disarmed lights operate on occupancy sensors. There are two button stations ON/OFF in the kitchen if the lights need to be overridden. When the rooms are un-occupied for 20 min lights cycle off. When the building arms, lights cycle off.
8. Exterior Lighting:
 - a. Parking lot lights to be turned "ON" 30 minutes before sunset and turned "OFF" at 11:30pm by astronomical clock.
 - b. Exterior building mounted lights to be turned "ON" 30 minutes before sunset by astronomical clock and turned "OFF" 15 minutes after the building is armed by security keypad. Provide integration of lighting control and intrusion detection system.
 - c. Dark campus during night time with exception of exterior lights dedicated to School Signage which need to be "ON" from dusk to dawn.
 - d. Parking lot lights, exterior fixture above door 130A and lights under canopy at front door to be "ON" at 5:45am and turned "OFF" 30 minutes after sunrise by astronomical clock. There is an additional sweep "OFF" at 8am.
 - e. Exterior building mounted lights to be "ON" after building is disarmed by security keypad and turned "OFF" 30 minutes after sunrise by astronomical clock. Provide integration of lighting control and intrusion detection system.
 - f. Exterior lighting at covered play area to be controlled together with the rest of the exterior lighting.
 - g. Parking lot lights, exterior building lights, covered play area and school signage to be also controlled by override switches in main electrical room E101.

B. Networking of digital controls:

1. Digital controls are located in Classrooms, Shared Learning Spaces, Circulation spaces, Commons and anywhere else with a lighting control unit. All digital lighting control units shall be networked together and tied back to a segment manager to enable metering by a personal. The owner shall provide a computer to reside in the Custodian office to run the lighting software.
2. Non digital controls do not need to be networked.

3.5 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 luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.6 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 operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

3.7 DEMONSTRATION

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

END OF SECTION 260923

SECTION 260943.23 - RELAY-BASED LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes: Lighting control panels using mechanically held relays for switching.
- B. Extent of lighting control system work is indicated by drawings and by the requirements of this section. It is the intent of this section to provide an integrated, energy saving lighting control system including Lighting Control Panels, Occupancy Sensors, and Daylighting Controls from a single supplier. Contractor is responsible for confirming that the panels and sensors interoperate as a single system.
- C. Lighting Control Panel shall have District network connection and communication through a single IP address coordinated with Division 27 design. The lighting control panel shall be interconnected with the building security system to shut off all controlled lighting when the security system is armed. The lighting control panel shall be programmed per District requirements. Other than egress lighting and exterior lighting, all other lighting control zones controlled by the lighting control panel shall allow the occupant to manually override the schedule through an input to the lighting control panel.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. IP: Internet protocol.
- C. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- D. PC: Personal computer; sometimes plural as "PCs."
- E. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Submit manufacturer's data on lighting control system and components including shop drawings, detailed wiring diagrams, and cut sheets as required under related specification sections. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, relays, manual switches and plates, and conductors and cables.
2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.

1.5 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 interface 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 comply with interoperability requirements of the network protocol.

B. Qualification Data: For testing agency.

C. Field quality-control reports.

D. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.

E. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On magnetic media or compact disk, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.7 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. Lighting Control Relays: Equal to 10% percent of amount installed, but no fewer than 1.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.
 - 2. Manufacturers: Firms regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.
 - 3. Comply with NEC, NEMA, and FCC requirements for Class A applications.
 - 4. UL Approvals: Relay panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Emergency relay panels shall be co-listed under UL 924 Emergency Lighting Equipment.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Handle and prepare panels for installation according to NECA 407.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Input signal from field-mounted manual switches, or digital signal sources, shall open or close one or more lighting control relays in the lighting control panels. Any combination of inputs shall be programmable to any number of control relays.

- 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 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with UL 916.

2.2 LIGHTING CONTROL PANELS

- A. Provide lighting control panels in the locations and capacities as indicated on the plans and schedules. Each panel shall be of modular construction and consist of the following components:
- B. Enclosure/Tub shall be NEMA 1, sized to accept an interior with 1 – 8 relays, 1 – 24 relays and 6 four-pole contactors, or 1 – 48 relays and 6 four-pole contactors.
- C. Cover shall be configured for surface or flush wall mounting of the panel as indicated on the plans. The panel cover shall have a hinged and lockable door with restricted access to line voltage section of the panel.
- D. Interior assembly shall be supplied as a factory assembled component specifically designed and listed for field installation. The interior construction shall provide total isolation of high voltage (Class 1) wiring from low voltage (Class 2) wiring within the assembled panel. The interior assembly shall include intelligence boards, power supply, DIN rails for mounting optional Class 2 control devices, and individually replaceable latching type relays. The panel interiors shall include the following features:
 - 1. Removable, plug-in terminal blocks with screwless connections for all low voltage terminations.
 - 2. Individual terminal block, override pushbutton, and LED status light for each relay.
 - a. Direct wired switch inputs associated with each relay and group channel shall support two- or three-wire, momentary or maintained contact switches or 24VDC input from occupancy sensors.
 - b. Automatic support for occupancy sensor sequence of operation. Direct wired low voltage inputs automatically reconfigure when connected to a WattStopper occupancy sensor head. Occupancy sensor shall switch lighting on and off during unoccupied periods but shall not turn lighting off during scheduled occupancy periods.
 - c. Digital inputs (four RJ-45 jacks) shall support 1-, 2-, 3-, 4-, and 8-button digital switches and digital occupancy sensors.
 - d. Isolated contacts within each relay shall provide true relay state to the electronics. True relay state shall be indicated by the on-board LED and shall be available to external control devices and systems.
 - e. Automatically sequenced operation of relays to reduce impact on the electrical distribution system when large loads are controlled simultaneously.
 - f. Group, channel, and pattern control of relays shall be provided through a simple keypad interface within the panel. Any group of relays can be associated with a channel for direct on/off control or pattern (scene) control via a simple

programming sequence using the relay and channel override pushbuttons and LED displays.

- g. Relay group status for each channel shall be provided through bi-color operation of the LED indicators. Solid red indicates that all relays in the group are on, solid green indicates that the group is in a mixed state, and blinking green indicates that the relays have blink warned and are currently timing out.
- h. Each relay and channel terminal block shall provide a 24V pilot light signal. It shall be possible to configure the system for support for any Class 2 pilot light voltage with the use of an auxiliary power supply.
- i. Single-pole latching relays with modular plug-in design. Relays shall provide the following ratings and features:

1) Electrical:

- a) 20 amp ballast at 277V
- b) 20 amp tungsten at 120V
- c) 1.5 HP motor at 120V
- d) 14,000 amp short circuit current rating (SCCR) at 277V

2) Mechanical:

- a) Individually replaceable, ½" KO mounting with removable Class 2 wire harness.
- b) Actuator on relay housing provides manual override and visual status indication, accessible from Class 2 section of panel.
- c) Dual line and load terminals each support two #14 – #12 solid or stranded conductors.
- d) Tested to 300,000 mechanical on/off cycles.
- e) Isolated low voltage contacts provide for true relay status feedback and pilot light indication.

- 3. Power supply shall be a multi-voltage transformer assembly with rated power to supply all electronics, occupancy sensors, switches, pilot lights, and photocells as necessary to meet the project requirements. Power supply to have internal over-current protection with automatic reset and metal oxide varistor protection.

E. Manufacturers: Greengate ControllKeeper and Wattstopper.

2.3 USER INTERFACE

A. Each lighting control panel shall be supplied with an integral user interface consisting of a keypad and associated OLED display screen. The user interface shall allow setup, configuration, and diagnostics of the panel without the need for software or connection of a computer. The user interface shall have the following functions as a minimum:

- 1. Set network parameters including panel device ID, MS/TP MAC address, baud rate and max master range.
- 2. Enter meaningful names for the panel, relays, and channels.
- 3. View normal hours/after hours status of each channel.

4. Override the normal hours/after hours mode for each channel.
5. View the 16 priority array slots for each channel and relay.
6. Program the schedule response for each channel as:
 - a. Automatic-on or manual-on.
 - b. Enable/disable blink warn.
 - c. Enter override time delay as 0 (none) to 240 minutes.

2.4 DIGITAL NETWORK SWITCHES

- A. Provide digital wall switches with 1, 2, 3, 4, or 8 buttons, in the colors indicated on the plans. Switches shall connect to the panel via standard Cat 5e cable with RJ-45 terminations. Digital wall switches shall have the following features:
1. Available colors: white, ivory, light almond, grey or black.
 2. Single gang device shall fit standard decorator opening and use standard wall plates.
 3. LED indicator on each button for status and locator function.
 4. Concealed configuration button with LED indicator for binding buttons to relays, no software or computer shall be required.
 5. Infrared window for use with handheld two-way wireless configuration tool,
 - a. Selectable function mode per button shall be momentary toggle (on/off), on only, or off only.
 - b. Removable button assembly for field color change or substitution of engraved buttons.
 - c. Two RJ-45 ports for connection to panel or other switches and/or occupancy sensors.
 - d. Open topology digital network via Cat 5e wire.
 - e. Digital switches shall be WattStopper LMSW series as indicated on the plans.

2.5 DIGITAL OCCUPANCY SENSORS

- A. Provide digital occupancy sensors to control relays in locations as shown on the plans. Sensors shall be either passive infrared, ultrasonic, or dual technology as indicated. Sensors shall be either ceiling or wall mounded and connect to the panel using Cat 5e cable with RJ-45 terminations. Digital occupancy sensors shall have the following features:
1. Setup and calibration shall be digital and precisely repeatable from sensor to sensor.
 2. User interface with pushbuttons and illuminated LCD screen for setup and calibration.
 3. Ladder-free setup and calibration with optional handheld two-way infrared commissioning tool.
 4. Sensitivity, 0 – 100% in 10% increments.
 5. Time delay, 1 – 30 minutes in 1 minute increments.
 6. Test mode with five-second time delay for simplified walk testing.
 7. Digital occupancy sensors shall be WattStopper LM series as indicated on the plans.

2.6 SCHEDULE, GROUP, AND PHOTOCELL CONTROL OF RELAYS

- A. The lighting control panel shall support schedule, group, and photocell control functions via the network as configured in the optional Segment Manager controller or building automation system. The lighting control panel shall be fully compatible with building automation systems that are BACnet compliant. See related specification sections for additional information on interfacing the lighting control panel(s) to the building automation system.

2.7 BROWSER-BASED PROGRAMMING AND CONTROL

- A. The digital segment manager shall be a compact controller capable of hosting the schedule, photocell, and group relay control functions for a network of up to 96 LILM series lighting control panels. The segment manager shall provide the following features:
 - 1. Provision for 1 to 3 separate network segments to facilitate efficient network wire routing.
 - 2. Compact housing with screw tab mounts for surface installation and integral DIN rail mounting slot for NEMA 1 installation in the LMSM-ENC1 enclosure.
 - 3. Web browser-based user interface; shall not require the installation of any lighting control software.
 - 4. User interface accessible from most smart phone browsers when Internet connected.
 - 5. Login security access control restricting some users to view-only or other limited operations.
 - 6. Automatic discovery of the lighting control panels.
 - 7. Familiar navigation-tree-based browsing to individual lighting control panels.
 - 8. View/override current status of channels and relays.
 - 9. Assign relays to channels.
 - 10. Set channel operating parameters:
 - a. Automatic-on or manual-on operation.
 - b. Enable/disable blink warn.
 - c. Override duration time, 0 (none) to 240 minutes.
 - d. AS-100 automatic wall switch operation mode.
 - 11. Create and run schedules:
 - a. Normal hours/after hours schedules for channels.
 - b. On/off schedules for relays.
 - c. Support for a minimum of 100 unique schedules, each with up to four time events per day.
 - d. Support annual schedules, holiday schedules and unique date-bound schedules.
 - 12. Ethernet connectivity for user access via direct-wired connection, LAN/WAN, or Internet connection.
 - 13. BACnet IP connectivity for connection to building automation systems.

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 and except in accessible ceiling spaces and in 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 260533 "Raceways and Boxes for Electrical Systems."
- C. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- D. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 PANEL INSTALLATION

- A. Comply with NECA 1.
- B. Install panels and accessories according to NECA 407.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- E. Mount panel cabinet plumb and rigid without distortion of box.
- F. 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 260553 "Identification for Electrical Systems."
- B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "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 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. 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.
- D. Acceptance Testing Preparation:
 - 1. Test continuity of each circuit.
- E. Lighting control panel will be considered defective if it does not pass tests and inspections.
- F. 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.

3.6 STARTUP SERVICE

- A. System Start Up and Commissioning
 - 1. Manufacturer shall provide a factory authorized technician to confirm proper installation and operation of the lighting control panels, switches, and occupancy sensors.

2. The technician shall provide training on the lighting control features of the system and shall verify that the panel(s) is communicating with the building automation system.
3. The system integrator or BAS vendor shall be responsible for all integration including the mapping of BACnet objects into the BAS logic, schedules and graphics.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to 2 visits to Project during other-than-normal occupancy hours for this purpose.

3.8 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.
- B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.
 1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.9 DEMONSTRATION

- A. Train owner's maintenance personnel to adjust, operate, and maintain the control unit and operator interface.

END OF SECTION 260943.23

SECTION 262200 - 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 SUBMITTALS

- A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

- C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

- D. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.3 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.4 COORDINATION

- A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Sector; Eaton Corporation; Cutler-Hammer Products.
 - 2. General Electric.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D Co./Groupe Schneider NA; Schneider Electric.

2.2 GENERAL TRANSFORMER REQUIREMENTS

- A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
- B. Cores: Grain-oriented, non-aging silicon steel.
- C. Coils: Continuous windings without splices except for taps.
 - 1. Internal Coil Connections: Brazed or pressure type.
 - 2. Coil Material: Aluminum.

2.3 DISTRIBUTION TRANSFORMERS

- A. Comply with NEMA ST 20, and list and label as complying with UL 1561.
- B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

- C. Cores: One leg per phase.
- D. Enclosure: Ventilated, NEMA 250, Type 2.
 - 1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
- E. Transformer Enclosure Finish: Comply with NEMA 250.
 - 1. Finish Color: Gray.
- F. Taps for Transformers Smaller Than 3 kVA: None.
- 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 two 2.5 percent taps below normal full capacity.
- I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.
- J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
 - 1. Complying with NEMA TP 1, Class 1 efficiency levels.
 - 2. Tested according to NEMA TP 2.
- K. 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.
- L. Wall Brackets: Manufacturer's standard brackets.
- M. Impedance Requirements: Transformers shall have minimum impedances as follows:
 - 1. 9 kVA and Less: 4.00%
 - 2. 30 to 50 kVA: 3.50%
 - 3. 51 to 150 kVA: 3.00%

2.4 IDENTIFICATION DEVICES

- A. Nameplates: Engraved, laminated-plastic or metal nameplate for each distribution transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.
- B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.
- C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.
- D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
 - 1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

3.3 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 ADJUSTING

- A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
- B. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.5 CLEANING

- A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 262200

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Surge protection devices (SPD).
3. Disconnecting and overcurrent protective devices.
4. Identification.
5. Built-in sub-metering per one-line diagram on drawing E5.1 and specification 260913.

1.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
- B. Shop Drawings: For each switchboard and related equipment.
 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detail short-circuit current rating and arc flash of switchboards and overcurrent protective devices.
 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

6. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.

1.5 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

- A. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA PB 2.
- D. Comply with NFPA 70.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

C. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.10 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.11 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

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
- C. Nominal System Voltage: 480Y/277 V.
- D. Main-Bus Continuous: 1200 A.
- E. Nominal System Voltage: 208Y/120 V.
- F. Main-Bus Continuous: 1200 A.
- G. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 " Seismic Controls for Electrical Systems."
- H. Indoor Enclosures: Steel, NEMA 250, Type 1.
- I. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- J. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; 16inged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features. Coordinate with one-line diagram on drawing E5.1.
- K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- L. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 SURGE PROTECTION DEVICES

- A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL 1449,

second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating.

- B. Peak Single-Impulse Surge Current Rating: 1600 kA per mode/320 kA per phase.
- C. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
- D. Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120-V, three-phase, four-wire circuits shall be as follows:
 - a. Line to Neutral: 400 V, 800 V from high leg.
 - b. Line to Ground: 400 V.
 - c. Neutral to Ground: 400 V.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: 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. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
 - c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.4 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NECA 400.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- E. Install filler plates in unused spaces of panel-mounted sections.
- F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

3.3 IDENTIFICATION

- A. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Arc Flash Label per NEC.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- B. Switchboard will be considered defective if it does not pass tests and inspections.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Panelboards.
 - 3. Built-in sub-metering per one-line diagram on drawing E5.1.

1.3 DEFINITIONS

- A. SPD: Surge protection device.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. 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 and arc flash of panelboards and overcurrent protective devices.

1.6 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.8 QUALITY ASSURANCE

- A. Comply with NEMA PB 1.
- B. Comply with NFPA 70.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.10 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.
 - 2. Altitude not exceeding 6600 feet (2000 m).

1.11 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 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.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Enclosures: Surface mounted cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Phase, Neutral, and Ground Buses:
 - 1. Material: Tin-plated aluminum.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

- D. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Tin-plated aluminum.
 - 2. Main and Neutral Lugs: Compression.
 - 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 - 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only as scheduled.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Double hinge cover, concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.3 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.

- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
- D. Mains: Circuit breaker.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker: Bolt-on circuit breakers.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - c. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - d. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - e. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
 - f. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.
- C. Panelboard Suppressors: Integrally mounted, wired-in, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating.
 - 1. Accessories:
 - a. Fuses rated at 200-kA interrupting capacity.
 - b. Fabrication using bolted compression lugs for internal wiring.
 - c. Integral disconnect switch.
 - d. Redundant suppression circuits.
 - e. Redundant replaceable modules.
 - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - g. LED indicator lights for power and protection status.

- h. Audible alarm, with silencing switch, to indicate when protection has failed.
 - i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation.
 - j. Four-digit, transient-event counter set to totalize transient surges.
- 2. Peak Single-Impulse Surge Current Rating: 80kA per mode/160kA per phase.
- 3. Minimum Single-Impulse Current Ratings, Using 8-by-20-Mic.Sec. Waveform:
 - a. Line to Neutral: 70,000 A.
 - b. Line to Ground: 70,000 A.
 - c. Neutral to Ground: 50,000 A.
- 4. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
- D. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:
 - 1. Line to Neutral: 800 V for 480Y/277.
 - 2. Line to Ground: 800 V for 480Y/277.
 - 3. Neutral to Ground: 800 V for 480Y/277.
- E. Protection modes and UL 1449 SVR for Grounded Wye Circuits with 208Y/120-V, Three-Phase, Four-Wire Circuits:
 - 1. Line to Neutral: 400 V for 208Y/120.
 - 2. Line to Ground: 400 V for 208Y/120.
 - 3. Neutral to Ground: 400 V for 208Y/120.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NECA 407.

3.2 INSTALLATION

- A. Install panelboards and accessories according to NECA 407.
- B. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

- E. Install overcurrent protective devices and controllers not already factory installed.
- F. Install filler plates in unused spaces.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- H. Comply with NECA 1.
- I. Provide 20% or more spare capacity for future expansion.
- J. Provide two additional $\frac{3}{4}$ " and two additional 1" spare conduits from each panelboard to space above for a minimum of 5'-0" or and as applicable below panelboard for future expansion.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Arc Flash label per NEC.

3.4 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- B. Panelboards will be considered defective if they do not pass tests and inspections.

3.5 ADJUSTING

- A. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Tamper-resistant receptacles.
 - 3. Snap switches and wall-box dimmers.
 - 4. Wall-switch occupancy sensors.
 - 5. Key switch
 - 6. Communications outlets.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. SPD: Surge protection device.
- F. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

- 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.

1.5 ACTION SUBMITTALS

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

1.6 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 2. Leviton Mfg. Company Inc. (Leviton).
 - 3. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, 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.

2.3 STRAIGHT-BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell; HBL5351 (single), HBL5352 (duplex).
 - b. Leviton; 5891 (single), 5352 (duplex).
 - c. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

- A. General Description:
 - 1. Straight blade, non-feed-through type.
 - 2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
 - 3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell; GFR5352L.
 - b. Pass & Seymour; 2095.
 - c. Leviton; 7590.

C. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498 Supplement sd, and FS W-C-596.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell; HBL8300SGA.
 - b. Leviton; 8300-SGG.
 - c. Pass & Seymour; TR63H.

D. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Hubbell; GFTR20.
 - b. Pass & Seymour; 2095TR.

2.5 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120 V, 20 A:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Single Pole:
 - 1) Hubbell; HBL1221.
 - 2) Leviton; 1221-2.
 - 3) Pass & Seymour; CSB20AC1.
 - b. Two Pole:
 - 1) Hubbell; HBL1222.
 - 2) Leviton; 1222-2.
 - 3) Pass & Seymour; CSB20AC2.

c. Three Way:

- 1) Hubbell; HBL1223.
- 2) Leviton; 1223-2.
- 3) Pass & Seymour; CSB20AC3.

d. Four Way:

- 1) Hubbell; HBL1224.
- 2) Leviton; 1224-2.
- 3) Pass & Seymour; CSB20AC4.

C. Key-Operated Switches, 120/277 V, 20 A:

1. Products: Subject to compliance with requirements, provide the following:
 - a. Pass & Seymour; no substitution.
2. Description: Momentary contact switch key for heavy-duty locking switch, 500K, with District-wide key standardization.

2.6 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Satin-finished type 302 stainless steel, beveled edge.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

2.7 FINISHES

A. Device Color:

1. Wiring Devices Connected to Normal Power System Panelboards: Gray unless otherwise indicated or required by NFPA 70 or device listing.
2. Wiring Devices Connected to Life Safety Generator Power Panelboards: Red.
3. Wiring Devices Connected to Stand-By Generator Power Panelboards: Blue.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. 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 boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- D. Device Installation:
 - 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
 - 6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
 - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 - 8. Tighten unused terminal screws on the device.
 - 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.

3.2 IDENTIFICATION

- A. Comply with Section 260553 "Identification for Electrical Systems."
- B. Identify each receptacle and switch. On the back of finish plate, use a label, or legibly write indelible ink, the panel number, circuit number and voltage for wiring device.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Cartridge fuses rated 600-V ac and less for use in enclosed switches and enclosed controllers.

1.3 ACTION SUBMITTALS

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

- 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.
- B. Comply with NEMA FU 1 for cartridge fuses.
- C. Comply with NFPA 70.

1.5 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cooper Bussmann, Inc.
 2. Ferraz Shawmut, Inc.
 3. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
1. Motor Branch Circuits: Class RK1, time delay.
 2. Other Branch Circuits: Class RK5, time delay.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Molded-case circuit breakers (MCCBs).
 - 4. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

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

1.8 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
 - 5. Cooper-Bussmann
 - 6. Ferraz-Shawmut
 - 7. Littelfuse
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Lugs: Suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Lugs: Suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. 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.

2.4 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 250, Type 3R.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Label each enclosure with engraved metal or laminated-plastic nameplate.

END OF SECTION 262816

SECTION 263100 - PHOTOVOLTAIC COLLECTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. PV modules (laminates in mounting frames).
 - 2. Inverters.
 - 3. Balance of System Components
 - 4. Mounting structures.

1.3 DEFINITIONS

- A. CEC: California Energy Commission.
- B. ETFE: Ethylene tetrafluoroethylene.
- C. FEP: Fluorinated ethylene propylene.
- D. IP Code: Required ingress protection to comply with IEC 60529.
- E. MPPT: Maximum power point tracking.
- F. PTC: USA standard conditions for PV.
- G. PV: Photovoltaic.
- H. STC: Standard Test Conditions defined in IEC 61215.

1.4 QUALIFICATIONS

- A. All work to be performed by a licensed and bonded electrical contractor. Photovoltaic System Installer shall have held a valid Oregon State electrical contractor's license, under the current business name, for a period of not less than 5 years.
- B. PV Installer shall have a NABCEP certified installer on staff.

1.5 BIDDING REQUIREMENTS AND SUBMITTAL

- A. The solar photovoltaic (PV) system will be a new ballasted system installation on new roof. The estimated total DC size of PV systems is 120 kW produced by PV panels installed on roof. This solar electric system is grid-interactive, and is designed to operate in parallel with the utility service. Ballasted racking will include minimal mechanical anchors to meet seismic requirements and shall be located by the racking manufacturer.
- B. The following information shall be provided to the general contractor at time of bid and will be used to review and select the winning bidder.
 - 1. Qualification information as required in section 1.4
 - 2. Proposed technologies with cut sheets. – Provide product data sheets for proposed solar modules, inverters, racking, data collector, and any other balance of system components.
 - 3. System Cost per Watt
 - 4. Total system size in kW, both DC and AC. – Provide system size in DC kW and AC kW for the proposed system.
 - 5. Simulation of annual performance using local weather data and proposed orientation and shading. – Provide simulated annual system production. Provide summary of data used in simulation such as shading information, total solar resource fraction (TSRF), and system de-rating parameters used.
 - 6. Example of roof attachment. – Provide a detail for the roof attachment for the proposed racking system.
 - 7. Partial or complete one-line diagram and plan view – Provide a basic one-line diagram showing proposed stringing and balance of system components (combines, disconnects, meters, etc). Provide a low level detail plan sheet(s) showing locations of equipment. This information is to purvey design intent only. Exact shop drawings to be provided during submittals.
 - 8. Warranty information – Provide information on product warranties and workmanship warranties
- C. If the PV design is to vary from what is shown in the documents (different technology, racking system, etc.) any re-engineering will be the responsibility of the PV Contractor and/or product manufacturer.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For PV modules.
 - 1. Include plans, elevations, sections, and mounting details.

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

1.7 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

1.9 WARRANTY

- A. Manufacturer's Special Materials and Workmanship Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.
 1. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:
 - a. Faulty operation of PV modules.
 2. Warranty Period: Two years from date of Substantial Completion.
- B. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.
 1. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Substantial Completion:
 - a. Specified minimum power output to 80 percent or more, for a period of 25 years.

PART 2 - PRODUCTS

2.1 PHOTOVOLTAIC MODULES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following or a prior approved equal:
1. Canadian Solar.
 2. Hanwha Q Cells Co.
 3. Hyundai Solar
 4. Itek Energy
 5. JA Solar.
 6. LG Electronics Inc.
 7. Panasonic/Sanyo North America Corporation.
 8. REC Solar
 9. SolarWorld
 10. SunPower Corporation.
 11. Trina Solar Limited.

2.2 INVERTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following or a prior approved equal:
1. Itek
 2. Chint
 3. SMA America
 4. Solectrica
 5. Enphase
- B. Inverters shall be string inverters or micro inverters. Central inverters must be approved by design team.

2.3 PERFORMANCE REQUIREMENTS

- A. NRTL (Nationally Recognized Testing Laboratory) Listing: Entire assembly shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for electrical and fire safety, Class A Class C, according to UL 1703.
- B. FM approved for NFPA 70, Class 1, Division 2, Group C and Group D hazardous locations.

2.4 SYSTEM DESCRIPTION

- A. Grid-Tied PV System:
1. Connected via a utility approved production meter to the electrical utility.

2. This solar electric system is grid-interactive, and it is designed to operate in parallel with the utility service.
3. The PV modules shall be installed on the rooftop. Attention should be paid in regards to setback distances from roof edges.
4. Inverters may be rooftop mounted, or if space permits, in an electrical room.
5. System shall include data collector to display system performance in a browser based format.
6. System Components:
 - a. PV modules.
 - b. Inverter.
 - c. Data collector
 - d. Overcurrent protection/combiner box.
 - e. Mounting structure.
 - f. Roof patching. (By roofing contractor).
 - g. Utility meter.
 - h. AC Utility Disconnect.
 - i. AC combiner panel
 - j. AC Tie Breaker
 - k. Associated conduit/raceways.

2.5 MANUFACTURED UNITS

- A. Cell Materials: Polycrystalline or Monocrystalline.
 1. c-Si.
 2. Gallium arsenide (GaAs).
- B. Module Construction:
 1. Nominal Size: 32 inches (800 mm) wide by 64 inches (1600 mm) long.
 2. Weight: 42.8 lb (19.4 kg).
- C. Front Panel: 0.125-inch- (3.2-mm-) thick glass.
- D. Backing Material: 0.125-inch- (3.2-mm-) thick glass;
- E. Bypass Diode Protection: Internal.
- F. Junction Box:
 1. Size: 1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm).
 2. Fully potted, vandal resistant.
 3. IP Code: IP65.
 4. Flammability Test: UL 1703.
- G. Output Cabling:
 1. 0.158 inch (4 mm).

2. Quick, multiconnect, polarized connectors.
3. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.

H. Series Fuse Rating: 15-20A.

2.6 CAPACITIES AND CHARACTERISTICS

A. Minimum Electrical Characteristics:

1. Maximum System Voltage: 1000VDC.
2. Rated Short-Circuit Current (I_{sc}): 20A Max.
3. Minimum Power at STC (P_{max}): 350W

B. Additional Electrical Characteristics:

1. Module Efficiency: 15 percent minimum.

2.7 MODULE FRAMING

A. PV laminates mounted in anodized extruded-aluminum frames.

1. Entire assembly UL listed for electrical and fire safety, Class A Class C, according to UL 1703, complying with IEC 61215.
2. Frame strength exceeding requirements of certifying agencies in subparagraph above.
3. Finish: Anodized aluminum.
 - a. Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
 - b. Color: As indicated by manufacturer's designations.

2.8 ARRAY CONSTRUCTION

A. Framing:

1. Material: Extruded aluminum.
2. Maximum System Weight: Less than 4 lb/sq. ft. (19.53 kg/sq. m).
3. Raceway Cover Plates: Aluminum.

2.9 INVERTER

- A. Control Type: Pulse width modulation control.
- B. Control Type: Maximum power point tracker control.
- C. Inverter Electrical Characteristics:

1. Maximum Recommended PV Input Power: 60 kW.
2. Maximum Voc: 1000W.
3. Number of String Inputs: as needed.
4. Nominal Output Voltage: 480/277V ac.
5. Minimum CEC Weighted Efficiency: 97 percent.
6. NEMA 250 Enclosure Rating: NEMA 3R.

D. Operating Conditions:

1. Operating Ambient Temperatures: Minus 4 to plus 122 deg F (20 to plus 50 deg C).
2. Storage Temperature: Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C).
3. Relative Humidity: 0 to 95 percent, noncondensing.

E. Enclosure:

1. NEMA 250, Type 3R.
2. Enclosure Material: Galvanized steel or Steel.
3. Cooling Methods:
 - a. Fan convection cooling.
 - b. Passive cooling.
4. Protective Functions:
 - a. AC over/under voltage.
 - b. AC over/under frequency.
 - c. Ground over current.
 - d. Overtemperature.
 - e. AC and dc overcurrent.
 - f. DC over voltage.
5. Standard liquid crystal display, four lines, 20 characters, with user display and on/off toggle switch.
6. Weight: 260 lb (118 kg).
7. Dimensions: 54 by 36 by 19 inches (137 by 91 by 48 cm).

F. Disconnects:

1. Low-voltage disconnect.
2. Low-voltage reconnect.
3. High-temperature disconnect.
4. High-temperature reconnect.

G. Regulatory Approvals:

1. IEEE 1547.1.
2. IEEE 1547.3.
3. UL 1741.

2.10 SYSTEM OVERCURRENT PROTECTION

- A. Combiner Box:
 - 1. Fuses: 15-20A sized per modules.
 - 2. Integral to inverter if string inverters are used.

2.11 BALANCE OF SYSTEM COMPONENTS

- A. AC Combiner Panelboard: Provide per specification section 262416.
- B. Interconnection Breaker: Provide compatible breaker in main switchboard 4MDP.
- C. Production meter Socket: Provide per utility standards
- D. AC utility Disconnect: Provide per utility standards.

2.12 MOUNTING STRUCTURES

- A. Roof Mount: Extruded aluminum, ballasted system, Panel Claw Polar Bear III HD or equal by:
 - 1. Unirac
 - 2. Or approved equal
- B. Coordinate locations and installation of racking anchor points with roofing contractor. Any patching, flashing, and sealing shall be done by roofing contractor to maintain roofing warranty.
- C. Coordinate with roofing specification section 075423 – Thermoplastic Polyolefin (TPO) Roofing.

PART 3 - EXECUTION

3.1 COORDINATION

- A. PV contractor to coordinate with general contractor (GC) and electrical contractor (EC) for scheduling and installation.
- B. PV contractor shall coordinate with utility for approval of interconnection. Utility required components (AC Disconnect, Meter socket, CT cabinet if required) shall be provided by PV contractor unless coordinated with EC to provide. All roof patching and welding over mounting standoffs for the racking system shall be done by the roofing contractor to ensure roof maintains its warranty.
- C. Coordinate with Beaverton School District IT personnel for data connection to data collection unit.

3.2 EXAMINATION

- A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Do not begin installation until mounting surfaces have been properly prepared.
- C. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
- D. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
- E. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.3 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections.
- C. PV module will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 263100

SECTION 263213 - ENGINE GENERATORS

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes packaged engine-generator sets for standby rated power supply with the following features:
 - 1. Diesel engine.
 - 2. Remote-mounting cooling system.
 - 3. Remote-mounting control and monitoring.
 - 4. Outdoor enclosure.
- B. See Division 263600 Section "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine-generator sets.

1.2 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.
- C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 260548.16 Section "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."
 - b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Source quality-control test reports.
- E. Field quality-control test reports.

- F. Operation and maintenance data.
- G. Warranty: Special warranty specified in this Section.

1.3 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 200 miles (321 km) 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. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
- K. 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.

1.4 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 3000 feet (900 m).

1.5 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.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1.7 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Caterpillar; Engine Div.
 - 2. Kohler Co.; Generator Division.
 - 3. Onan/Cummins Power Generation; Industrial Business Group.

2.2 ENGINE-GENERATOR SET

- A. Factory-assembled and -tested, engine-generator set.
- B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
- C. Capacities and Characteristics:
 - 1. Power Output Ratings: Nominal ratings as indicated.
 - 2. Output Connections: Three-phase, four wire.
 - 3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: 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: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

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.

- F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
- G. Governor: Adjustable isochronous, with speed sensing.
- H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
 - 1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
 - 2. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
- I. Air-Intake Filter: Standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
- J. Starting System: 12-V electric, with negative ground.
 - 1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
 - 2. Cranking Motor: Heavy-duty 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 Part 1 "Project Conditions" Article to provide specified cranking cycle at least twice without recharging.
 - 5. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
 - a. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.

2.4 FUEL OIL STORAGE

- A. Comply with NFPA 30.
- B. Base-Mounted Fuel Oil Tank with dual sub-base wall: Factory installed and piped, complying with UL 142 fuel oil tank.
- C. Generator manufacturer to provide the following:
 - 1. Tank level indicator.
 - 2. Capacity: Fuel for 96 hours' continuous operation at 100 percent rated power output, minimum 600 gal fuel tank.
 - 3. Vandal-resistant fill cap.
 - 4. Containment: Integral rupture basin with a nominal capacity of day tank.
 - 5. Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.

6. Normal atmospheric vent shall not be less than 12 ft above adjacent grade, nor located for trapped vapors under eaves, and at least 5 feet from building openings or property lines per IFC 5704.2.7.3.3.

2.5 CONTROL AND MONITORING

- A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
- B. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
- C. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 system, and the following:
 1. AC voltmeter.
 2. AC ammeter.
 3. AC frequency meter.
 4. DC voltmeter (alternator battery charging).
 5. 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. Fuel tank derangement alarm.
 11. Fuel tank high-level shutdown of fuel supply alarm.
 12. Generator overload.
- D. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
- E. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
 1. Overcrank shutdown.
 2. Coolant low-temperature alarm.
 3. Control switch not in auto position.
 4. Battery-charger malfunction alarm.
 5. Battery low-voltage alarm.
- F. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual

indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.

- G. Remote alarm annunciator panel for emergency generator shall be located in the main office.

2.6 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: Connected to trip breaker when generator set is shut down by other protective devices.
 - 4. Mounting: Adjacent to or integrated with control and monitoring panel.

2.7 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

- A. Comply with NEMA MG 1.
- B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
- 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 shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
- F. Enclosure: Dripproof.
- G. Instrument Transformers: Mounted within generator enclosure.
- H. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
 - 1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
- I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
- J. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
- K. Subtransient Reactance: 12 percent, maximum.

2.8 OUTDOOR GENERATOR-SET ENCLOSURE

- A. Description: Vandal-resistant, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.
- B. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
 - 1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
 - 2. The enclosure shall be designed to reduce the overall noise level at full load operation to an average of 71 dBA at 23 feet from the generator set, in a free field environment.

2.9 VIBRATION ISOLATION DEVICES

- A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
 - 1. Material: Standard neoprene.
 - 2. Durometer Rating: 50.
 - 3. Number of Layers: Two.

2.10 FINISHES

- A. Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.11 SOURCE QUALITY CONTROL

- A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
 - 1. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
 - 2. Report factory test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

- B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
- C. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch (25 mm) on 8-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Seismic Controls for Electrical Systems."
- D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
 - 1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping."
- E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
- F. Piping installation requirements are specified in Division 23 Sections. Drawings indicate general arrangement of piping and specialties.
- G. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
- H. Connect engine exhaust pipe to engine with flexible connector.
- I. Connect fuel piping to engines with a gate valve and union and flexible connector.
 - 1. Diesel storage tanks, tank accessories, piping, valves and specialties for fuel systems are specified in Division 23 Section "Facility Fuel-Oil Piping and Systems."
- J. Ground equipment for separate derived system according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- K. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- L. Identify system components according to Division 23 Section "Identification for HVAC Piping and Equipment" and Division 26 Section "Identification for Electrical Systems."
- M. Provide housekeeping pad per manufacturer's requirements.

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
 3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
 - a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
 - b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
 - c. Verify acceptance of charge for each element of the battery after discharge.
 - d. Verify that measurements are within manufacturer's specifications.
 4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
 5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
 6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
 7. Exhaust Emissions Test: Comply with applicable government test criteria.
 8. 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.
 9. 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.
 10. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
- C. Coordinate tests with tests for transfer switches and run them concurrently.
- D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
- E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

- F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- G. Remove and replace malfunctioning units and retest as specified above.
- H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
- I. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.3 DEMONSTRATION

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

END OF SECTION 263213

SECTION 263600 - 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. Section includes transfer switches rated 600 V and less, including the following:
 - 1. Automatic transfer switches.

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.

1.4 INFORMATIONAL SUBMITTALS

- A. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Section 260548 "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 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.
- B. Field quality-control 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 Section 017823 "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. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NEMA ICS 1.
- C. Comply with NFPA 70.
- D. Comply with NFPA 99.
- E. Comply with NFPA 110.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Contactor Transfer Switches:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Caterpillar; Engine Div.
 - b. Emerson; ASCO Power Technologies, LP.
 - c. Kohler Power Systems; Generator Division.
 - d. Onan/Cummins Power Generation; Industrial Business Group.
 - e. Russelectric, Inc.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

- A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer.
- B. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.

1. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
- C. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.
- D. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
- E. Electrical Operation: Accomplish by a 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.
- 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. 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. 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. 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.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
 - a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
 - b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
12. 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.

2.4 SOURCE QUALITY CONTROL

- A. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Section 260548.16 "Seismic Controls for Electrical Systems."
- B. Identify components according to Section 260553 "Identification for Electrical Systems."
- C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

- A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 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:
 - 1. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. 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.
 - 3. 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. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- C. Coordinate tests with tests of generator and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
- E. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below. Refer to Section 017900 "Demonstration and Training."
- B. Coordinate this training with that for generator equipment.

END OF SECTION 263600

SECTION 265100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Interior solid-state luminaires that use LED technology.
 - 2. Exit signs.
 - 3. Lighting fixture supports.

- B. Related Sections:

- 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including lighting control units, photoelectric sensors, and occupancy sensors.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color-rendering index.
- C. LER: Luminaire efficacy rating.
- D. Lumen: Measured output of lamp and luminaire, or both.
- E. Luminaire: Complete lighting fixture, including ballast housing if provided.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
 - 1. Physical description of lighting fixture including dimensions.
 - 2. Driver.
 - 3. Energy-efficiency data.
 - 4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
 - 5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture

type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

- a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
- B. Shop Drawings: For nonstandard or custom lighting fixtures. 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. Wiring Diagrams: For power, signal, and control wiring.
- C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each
- D. Installation instructions.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- B. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures, from manufacturer.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.
 1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

1.7 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. Drivers and LED boards for downlights: Provide 5 extra drivers and led boards for adjustable CCT downlights. Provide 2 extra drivers for detention grade fixtures.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- E. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.
 - 1. Obtain Architect's approval of luminaires in mockups before starting installations.
 - 2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
 - 3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
 - 4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 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.

1.11 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated on Drawings or a prior approved equal.

2.2 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7
- B. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.
 - 1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.3 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. Bulb shape complying with ANSI C79.1.
- F. Lamp base complying with ANSI C81.61.
- G. CRI of minimum of 80. CCT variable or as called out on fixture schedule.
- H. Rated lamp life of 50,000 hours.
- I. Lamps dimmable from 100 percent to 10 percent of maximum light output.
- J. Internal driver.
- K. Nominal Operating Voltage: 120 V ac.
 - 1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.4 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage, and coating.
 - c. CCT and CRI for all luminaires.

2.5 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.6 LUMINAIRE FIXTURE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Single-Stem Hangers: 1/2-inch (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.
- C. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).
- D. Rod Hangers: 3/16-inch (5-mm) minimum diameter, cadmium-plated, threaded steel rod.
- E. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
 - 1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

3.3 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

PART 4 - EXECUTION

4.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install per manufacturer's requirements.
- D. Install lamps in each luminaire.
- E. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.

- F. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

4.2 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

4.3 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 - 2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.
- C. Prepare test and inspection reports.

4.4 STARTUP SERVICE

- A. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."
- B. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in LED fixtures intended to be dimmed, for at least 100 hours at full voltage.

END OF SECTION 265100

SECTION 265600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Exterior luminaires with lamps and ballasts.
 - 2. Luminaire-mounted photoelectric relays.
 - 3. Poles and accessories.
 - 4. Luminaire lowering devices.

- B. Related Sections:

- 1. Section 265100 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color-rendering index.
- C. LER: Luminaire efficacy rating.
- D. Luminaire: Complete lighting fixture, including ballast housing if provided.
- E. Pole: Luminaire support structure, including tower used for large area illumination.
- F. Standard: Same definition as "Pole" above.

1.4 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

- A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.
- B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4-M.
- C. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.

- D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.
1. Basic wind speed for calculating wind load for poles exceeding 49.2 feet (15 m) in height is 100 mph (45 m/s).
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 50 years.
 - c. Velocity Conversion Factors: 1.0.
 2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s).
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 25 years.
 - c. Velocity Conversion Factors: 1.0.

1.5 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. Ballasts, including energy-efficiency data.
 8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency 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, if indicated.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

1.6 INFORMATIONAL SUBMITTALS

- A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

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

1.8 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. Lamps: One for every 100 of each type and rating installed. Furnish at least one of each type. None required for LEDs.

1.9 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.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Package aluminum poles for shipping according to ASTM B 660.
- B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.
- C. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.11 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:
 2. Warranty Period for Metal Corrosion: Five years
 3. Warranty Period for Color Retention: Five years
 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated on Drawings or a prior approved equal.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

- A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
 2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
 3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.
- B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- C. Metal Parts: Free of burrs and sharp corners and edges.
- D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
- E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during

relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

- G. Exposed Hardware Material: Stainless steel.
- H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field. Shields for LED fixtures shall be integrated into the individual LED optics.
- J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- M. Factory-Applied Finish for Steel luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
 - 2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.
- N. Factory-Applied Finish for Aluminum luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
 - 1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 - 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.

- O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and ballasts. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:

- a. "USES ONLY" and include specific lamp type.
- b. Lamp diameter code (T-4, T-5, T-8, T-12), tube configuration (twin, quad, triple), base type, and nominal wattage for fluorescent and compact fluorescent luminaires.
- c. Lamp type, wattage, bulb type (ED17, BD56, etc.) and coating (clear or coated) for HID luminaires.
- d. Start type (preheat, rapid start, instant start) for fluorescent and compact fluorescent luminaires.
- e. ANSI ballast type (M98, M57, etc.) for HID luminaires.
- f. CCT and CRI for all luminaires.

2.3 LED SYSTEMS

- A. The LED module itself and all its components must not be subjected to mechanical stress.
- B. Assembly must not damage or destroy conducting patches on the circuit board.
- C. Installation of LED modules (with power supplies) shall adhere to all applicable electrical and safety standards.
- D. Correct electrical polarity shall be clearly identified.
- E. LED module must be protected from unbalanced voltage drop, and/or overload.
- F. Ensure that the power supply is of adequate power to operate the total load.
- G. Utilized ESD precautions when installing the module.
- H. Install system according to the manufacturer's heat sinking parameters.
- I. For applications involving exposure to humidity and dust, the module shall be protected by a fixture or housing with a suitable protection glass. The module shall be protected against condensation water by treatment with an appropriate circuit board conformal coating. The conformal coating should have the following features:
 1. Optical transparency.
 2. UV resistance.
 3. Thermal expansion properties matching those of the module.
 4. Low permeability of steam for all climate conditions.
 5. Resistance against corrosive environments.
- J. The LED module shall be operated with an electronically stabilized power supply including protection against short circuits, overload, and overheating.

- K. All LED products shall have a UL listed label. Unlicensed products are not acceptable.

2.4 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.
- 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 (65 by 130 mm), 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 Section 033000 "Cast-in-Place Concrete."

2.5 STEEL POLES

- A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.
1. Shape: Round, tapered.
 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Brackets for Luminaires: Detachable, cantilever, without underbrace.
1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with galvanized-steel bolts.
 2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
 3. Match pole material and finish.
- C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

- D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
- E. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.
- F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

2.6 POLE ACCESSORIES

- A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.
- B. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept indicated accessories.

2.7 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.

2.8 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 (1520 mm).
 - 2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).
 - 3. Trees: 15 feet (5 m) 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 Section 033000 "Cast-in-Place Concrete."
- D. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

- E. Raise and set poles using web fabric slings (not chain or cable).

2.9 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

2.10 GROUNDING

- A. Ground metal poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.
- B. Ground nonmetallic poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding conductor and conductor protector.
 - 2. Ground metallic components of pole accessories and foundations.

2.11 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
- C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 265600

SECTION 270526 - GROUNDING AND BONDING FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. BCT: Bonding conductor for telecommunications.
- B. TGB: Telecommunications grounding busbar.
- C. TMGB: Telecommunications main grounding busbar.
- D. Service Provider: The operator of a service that provides telecommunications transmission delivered over access provider facilities.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: For communications equipment room signal reference grid. Include plans, elevations, sections, details, and attachments to other work.

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing as-built locations of grounding and bonding infrastructure, including the following:
 - 1. BCT, TMGB, TGBs, and routing of their bonding conductors.
- B. Qualification Data: For Installer, installation supervisor, and field inspector.
- C. Qualification Data: For testing agency and testing agency's field supervisor.
- D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Result of the ground-resistance test, measured at the point of BCT connection.
 - b. Result of the bonding-resistance test at each TGB and its nearest grounding electrode.

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 ITS 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 designer RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Comply with TIA-607-B.

2.2 CONDUCTORS

- A. Available Manufacturers:
 1. Harger Lightning and Grounding.
 2. Panduit Corp.
 3. Tyco Electronics Corp.
 4. Chatsworth Products, Inc.
- 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. Cable Tray Grounding Jumper:

1. Not smaller than No. 6 AWG and not longer than 12 inches (300 mm). If jumper is a wire, it shall have a crimped grounding lug with two holes and long barrel for two crimps. If jumper is a flexible braid, it shall have a one-hole ferrule. Attach with grounding screw or connector provided by cable tray manufacturer.

E. 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 (14.2 sq. mm), 14 strands of No. 17 AWG conductor, and 1/4 inch (6.3 mm) 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 (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

A. Available Manufacturers:

1. Burndy; Part of Hubbell Electrical Systems.
2. Chatsworth Products, Inc.
3. Harger Lightning and Grounding.
4. Panduit Corp.
5. Tyco Electronics Corp.

B. 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.

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 or exothermic-type, mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (15.8- or 25.4-mm) 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. Available Manufacturers:

1. Chatsworth Products, Inc.
 2. Harger Lightning and Grounding.
 3. Panduit Corp.
- B. TMGB: Predrilled, wall-mounted, rectangular bars of hard-drawn solid copper, 1/4 by 4 inches (6.3 by 100 mm) in cross section, length as indicated on Drawings. The busbar shall be NRTL listed for use as TMGB and shall comply with TIA-607-B.
1. Predrilling shall be with holes for use with lugs specified in this Section.
 2. Mounting Hardware: Stand-off brackets that provide a 4-inch (100-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- C. TGB: Predrilled rectangular bars of hard-drawn solid copper, 1/4 by 2 inches (6.3 by 50 mm) 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-B.
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 (50-mm) clearance to access the rear of the busbar. Brackets and bolts shall be stainless steel.
 3. Stand-off insulators for mounting shall be Lexan or PVC. Comply with UL 891 for use in 600-V switchboards, impulse tested at 5000 V.
- 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-B. Predrilling shall be with holes for use with lugs specified in this Section.
1. Cabinet-Mounted Busbar: Terminal block, with stainless-steel or copper-plated hardware for attachment to the cabinet.
 2. Rack-Mounted Horizontal Busbar: Designed for mounting in 19- or 23-inch (483- or 584-mm) equipment racks. Include a copper splice bar for transitioning to an adjoining rack, and stainless-steel or copper-plated hardware for attachment to the rack.
 3. Rack-Mounted Vertical Busbar: 72 or 36 inches (1827 or 914 mm) long, with stainless-steel or copper-plated hardware for attachment to the rack.

2.5 IDENTIFICATION

- A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. 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 (10 mm). 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 BCT connection.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with connection of the BCT only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Bonding shall include the ac utility power service entrance, the communications cable entrance, and the grounding electrode system. The bonding of these elements shall form a loop so that each element is connected to at least two others.
- B. Comply with NECA 1.
- C. Comply with TIA-607-B.

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 TGB and structural steel of steel-frame buildings shall not be smaller than No. 3/0 AWG.
 - 2. The bonding conductors between the TMGB and structural steel of steel-frame buildings shall not be smaller than No. 3/0 AWG.
- B. Underground Grounding Conductors: Install bare tinned-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 (900 mm).

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 (900-mm) intervals.
4. Install grounding and bonding conductors in 3/4-inch (21-mm) 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 Division 27 and bond both ends of the conduit to a TGB.

3.4 GROUNDING ELECTRODE SYSTEM

- A. The BCT between the TMGB and the ac service equipment ground shall not be smaller than No. 3/0 AWG.

3.5 GROUNDING BUSBARS

- A. Indicate locations of grounding busbars on Drawings. Install busbars horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 12 inches (300 mm) 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 TMGB with insulated bonding conductor.
- E. Interconnections: Interconnect all TGBs with the TMGB with the telecommunications backbone conductor. If more than one TMGB is installed, interconnect TMGBs using the grounding equalizer conductor. The telecommunications backbone conductor and grounding equalizer conductor size shall not be less than 2 kmils/linear foot (1 sq. mm/linear meter) of conductor length, up to a maximum size of No. 3/0 AWG unless otherwise indicated.
- F. Telecommunications Enclosures and Equipment Racks: Bond metallic components of enclosures to the telecommunications bonding and grounding system. Install vertically mounted rack grounding busbar unless the enclosure and rack are manufactured with the busbar. Bond the equipment grounding busbar to the TGB 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 TGB and TMGB 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 TGB to the ground bar of the panelboard.
- I. Shielded Cable: Bond the shield of shielded cable to the TGB in communications rooms and spaces. Comply with TIA-568-C.1 and TIA-568-C.2 when grounding shielded 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. Equipment Room Signal Reference Grid: Provide a low-impedance path between telecommunications cabinets, equipment racks, and the reference grid, using No. 6 AWG bonding conductors.
 1. Install the conductors in grid pattern on 4-foot (1200-mm) centers, allowing bonding of one pedestal from each access floor tile.
 2. Bond the TGB of the equipment room to the reference grid at two or more locations.
 3. Bond all conduits and piping entering the equipment room to the TGB at the perimeter of the room.

3.7 IDENTIFICATION

- A. Labels shall be preprinted or computer-printed type.
 1. Label TMGB(s) with "fs-TMGB," where "fs" is the telecommunications space identifier for the space containing the TMGB.
 2. Label TGB(s) with "fs-TGB," where "fs" is the telecommunications space identifier for the space containing the TGB.

3. Label the BCT and each telecommunications backbone conductor at its attachment point: "WARNING! TELECOMMUNICATIONS BONDING CONDUCTOR. DO NOT REMOVE OR DISCONNECT!"

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 TMGB and a TGB 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 TMGB and in each TGB. Maximum acceptable ac current level is 1 A.
- C. Excessive Ground Resistance: If resistance to ground at the BCT 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 270526

SECTION 270527 - PATHWAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid conduit.
- C. IMC: Intermediate metal conduit.

1.3 ACTION SUBMITTALS

- A. Product data for the following:
 - 1. Surface pathways.
 - 2. Wireways and fittings.
 - 3. Boxes, enclosures, and cabinets.
 - 4. Underground handholes and boxes.
- B. Shop Drawings: For custom enclosures and cabinets and custom underground handholes and boxes. Include plans, elevations, sections, and attachment details.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Pathway routing plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of items involved:
 - 1. Structural members in paths of pathway groups with common supports.
 - 2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.
 - 3. Underground ducts, piping, and structures in location of underground enclosures and handholes.
- B. Qualification Data: For professional engineer.

- C. Seismic Qualification Data: Provide seismic bracing for all pathway racks, enclosures, cabinets, equipment racks, and their mounting provisions, including those for internal components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
 - 4. Detailed description of conduit support devices and interconnections on which certification is based and their installation requirements.
- D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit.
 - 3. Alpha Wire Company.
 - 4. Anamet Electrical, Inc.
 - 5. Electri-Flex Company.
 - 6. O-Z/Gedney.
 - 7. Picoma Industries.
 - 8. Republic Conduit.
 - 9. Robroy Industries.
 - 10. Southwire Company.
 - 11. Thomas & Betts Corporation.
 - 12. Western Tube and Conduit Corporation.
 - 13. Wheatland Tube Company.
- B. General Requirements for Metal Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by a nationally recognized testing laboratory, and marked for intended location and application.
 - 2. Comply with TIA-569-D.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.

- F. PVC-Coated Steel Conduit: PVC-coated GRC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch (1 mm), minimum.
- G. EMT: Comply with ANSI C80.3 and UL 797.
- H. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel or die cast.
 - b. Type: compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL-467, rated for environmental conditions where installed, and including flexible external bonding jumper.
 - 4. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.
- I. Joint Compound for IMC, GRC, or ARC: 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 CONDUITS AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit.
 - 3. Anamet Electrical, Inc.
 - 4. Arnco Corporation.
 - 5. CANTEX Inc.
 - 6. CertainTeed Corporation.
 - 7. Condux International, Inc.
 - 8. Electri-Flex Company.
 - 9. Kraloy.
 - 10. Lamson & Sessions; Carlon Electrical Products.
 - 11. Niedax-Kleinhuis USA, Inc.
 - 12. RACO; Hubbell.
 - 13. Thomas & Betts Corporation.
- B. General Requirements for Nonmetallic Conduits and Fittings:
 - 1. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.

2. Comply with TIA-569-D.

- C. RNC: Type EPC-40-PVC, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
- D. Rigid HDPE: Comply with UL 651A.
- E. Continuous HDPE: Comply with UL 651A.
- F. RTRC: Comply with UL 2515A and NEMA TC 14.
- G. Fittings: Comply with NEMA TC 3; match to conduit or tubing type and material.

2.3 OPTICAL-FIBER-CABLE PATHWAYS AND FITTINGS

- A. Description: Comply with UL 2024; flexible-type pathway with a circular cross section, approved for riser or general-use installation unless otherwise indicated.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. INNERDUCT.
 - 2. Alpha Wire Company.
 - 3. Arnco Corporation.
 - 4. Endot Industries Inc.
 - 5. IPEX.
 - 6. Lamson & Sessions; Carlon Electrical Products.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.

2.4 SURFACE METAL PATHWAYS

- A. Description: Galvanized steel with snap-on covers, complying with UL 5.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Mono-Systems, Inc.
 - b. Niedax-Kleinhuis USA, Inc.
 - c. Panduit Corp.
 - d. Wiremold / Legrand.
 - e. Cooper B-Line, Inc.; a Division of Cooper Industries
 - f. Hoffman; a brand of Pentair Equipment Protections
 - g. Square D.

- B. Finish: Manufacturer's standard enamel finish in color selected by Architect.
- C. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- D. Comply with TIA-569-D.

2.5 HOOKS

- A. Description: Prefabricated sheet metal cable supports for telecommunications cable.
- B. Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- C. Comply with TIA-569-D.
- D. Galvanized steel.
- E. J shape.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Description: Enclosures for communications.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. Hoffman.
 - 5. Lamson & Sessions; Carlon Electrical Products.
 - 6. Milbank Manufacturing Co.
 - 7. Mono-Systems, Inc.
 - 8. O-Z/Gedney.
 - 9. Quazite:Hubbell Power Systems, Inc.
 - 10. RACO; Hubbell.
 - 11. Robroy Industries.
 - 12. Spring City Electrical Manufacturing Company.
 - 13. Thomas & Betts Corporation.
 - 14. Wiremold / Legrand.
- C. General Requirements for Boxes, Enclosures, and Cabinets:
 - 1. Comply with TIA-569-D.
 - 2. Boxes, enclosures, and cabinets installed in wet locations shall be listed and labeled as defined in NFPA 70, by an NRTL, and marked for use in wet locations.

3. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
 4. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
 5. Gangable boxes are prohibited.
- D. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- E. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.
- F. Metal Floor Boxes:
1. Comply with requirements in division 26 for multi-service floor boxes serving electrical, communications and audio/video systems.
- G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- H. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- I. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 and Type 3R, with continuous-hinge cover with flush latch unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 2. Nonmetallic Enclosures:
 - a. Material: Fiberglass.
 3. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
1. NEMA 250, Type 1 and Type 3R galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Accessory feet where required for freestanding equipment.
 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Outdoors: Apply pathway products as specified below unless otherwise indicated:

1. Exposed Conduit: GRC.
 2. Concealed Conduit, Aboveground: GRC.
 3. Underground Conduit: RNC, Type EPC-40-PVC.
 4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: EMT.
 2. Exposed, Not Subject to Severe Physical Damage: EMT.
 3. Exposed and Subject to Severe Physical Damage: GRC. Pathway locations include the following:
 - a. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - b. Mechanical rooms.
 - c. Gymnasiums
 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 5. Damp or Wet Locations: GRC.
 6. Pathways for Optical-Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical-fiber-cable pathway.
 7. Pathways for Optical-Fiber or Communications-Cable Risers in Vertical Shafts: Riser-type, optical-fiber-cable pathway.
 8. Pathways for Concealed General-Purpose Distribution of Optical-Fiber or Communications Cable: General-use, optical-fiber-cable pathway.
 9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel units in institutional and commercial kitchens and damp or wet locations.
- C. Minimum Pathway Size: 1-inch (25-mm) trade size for copper and aluminum cables, and 1 inch (25 mm) for optical-fiber cables.
- D. Pathway Fittings: Compatible with pathways and suitable for use and location.
1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 3. EMT: Use compression fittings. Comply with NEMA FB 2.10.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Install surface pathways only where indicated on Drawings. Do not install surface pathways without requesting prior authorization from Architect/Engineer.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F (49 deg C).

3.2 INSTALLATION

- A. Comply with the following standards for installation requirements except where requirements on Drawings or in this Section are stricter:
 - 1. NECA 1.
 - 2. NECA/BICSI 568.
 - 3. TIA-569-D.
 - 4. NECA 101
 - 5. NECA 105.
- B. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- C. Comply with requirements in division 07 for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.
- D. Comply with requirements in division 27 for hangers and supports.
- E. Comply with requirements in division 27 for sleeves and sleeve seals for communications.
- F. Keep pathways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.
- G. Complete pathway installation before starting conductor installation.
- H. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- I. Conceal rigid conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- J. Support conduit within 12 inches (300 mm) of enclosures to which attached.
- K. Pathways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch (27-mm) 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 (3-m) intervals.
 - 2. Arrange pathways to cross building expansion joints at right angles with expansion fittings. Comply with requirements for expansion joints specified in this article.
 - 3. Arrange pathways to keep a minimum of 1 inch (25 mm) of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from nonmetallic conduit and fittings to GRC and fittings before rising above floor.
- L. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for pathways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- M. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- N. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus one additional quarter-turn.
- O. 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.
- P. Cut conduit perpendicular to the length. For conduits of 2-inch (50-mm) trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- Q. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire. Secure pull wire, so it cannot fall into conduit. Cap pathways designated as spare alongside pathways in use.
- R. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:
 1. 3/4-Inch (21-mm) Trade Size and Smaller: Install pathways in maximum lengths of 50 feet (15 m).
 2. 1-Inch (25-mm) Trade Size and Larger: Install pathways in maximum lengths of 75 feet (23 m).
 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- S. Install pathway-sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed pathways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install pathway-sealing fittings according to NFPA 70.
- T. Install devices to seal pathway interiors at accessible locations. Locate seals, so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all pathways at the following points:
 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where an underground service pathway enters a building or structure.
 3. Where otherwise required by NFPA 70.
- U. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- V. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m). Install in each run of aboveground RMC and EMT that is located where environmental temperature change may exceed 100 deg F (55 deg C), and that has straight-run length that exceeds 100 feet (30 m).
 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 (70 deg C) temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
 - d. Attics: 135 deg F (75 deg C) 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 (0.06 mm per meter of length of straight run per deg C) 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 (0.0115 mm per meter of length of straight run per deg C) 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.
- W. Hooks:
1. Size to allow a minimum of 25 percent future capacity without exceeding design capacity limits.
 2. Shall be supported by dedicated support wires. Do not use ceiling grid support wire or support rods.
 3. Hook spacing shall allow no more than 6 inches (150 mm) of slack. The lowest point of the cables shall be no less than 6 inches (150 mm) adjacent to ceilings, mechanical ductwork and fittings, luminaires, power conduits, power and telecommunications outlets, and other electrical and communications equipment.
 4. Space hooks no more than 5 feet (1.5 m) o.c.
 5. Provide a hook at each change in direction.
- X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- Y. Coordinate communications device box location with electrical outlet boxes. Devices should be located no more than 6-inches from one another.

- Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall. Prepare block surface to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- AA. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- BB. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- CC. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- DD. Set metal floor boxes level and flush with finished floor surface.
- EE. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 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 (12.5-mm) sieve to No. 4 (4.75-mm) 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 (25 mm) above finished grade.
- D. Install handholes with bottom below frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.

3.4 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in division 27.

3.5 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in division 07.

3.6 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 270528

SECTION 270528 - PATHWAYS FOR AUDIO VISUAL SYSTEMS

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Work Specified Elsewhere:
 - 1. Division 26 and associated electrical, power and grounding requirements.
 - 2. Division 27 and associated Drawings.

1.2 SUMMARY

- A. This Section includes:
 - 1. Raceway systems, conduit, boxes, cover plates, enclosures, terminal cabinets and terminal boards.
 - 2. Electrical work related to all Base Bid and Alternate A/V systems. Provide this work for both Base Bid and Alternate A/V systems, even if Alternates are not accepted.
- B. Under this section, provide raceway systems for the installation of audio systems. Installation shall include appropriately sized metallic raceways, outlet boxes, plaster rings, cover plates and installation of pull strings.

1.3 ADMINISTRATIVE REQUIREMENTS

- A. Related work by others includes: A/V system installation by the A/V systems subcontractor(s).
- B. Under this Section, coordinate with A/V system Contractor on:
 - 1. Wiring methods and A/V systems conduit/junction back boxes locations and sizing.
 - 2. Equipment rack locations, speaker locations, device locations, terminal boxes, electrical outlets and services, gutters and chases, all as required to supply an infrastructure capable of supporting the installation of Base Bid and Alternate A/V Systems.

1.4 SUBMITTALS

- A. Submit product data, shop drawings and other submittals for this work separately from the other Sections of Division 16 for review by Electrical and A/V system consultants.

1.5 COORDINATION

- A. Coordinate work in this Section with the A/V systems subcontractor(s).

PART 2 PRODUCTS

2.1 EQUIPMENT AND MATERIALS

- A. Except as otherwise specified in this Section, provide products, materials, and services for A/V systems infrastructure in accordance with other Sections of Division 16.
- B. If remodeling is part of scope, existing raceways may be reused, per NEC and local codes. Connect and extend existing conduits to rack or device locations, if such conduit exists.
- C. Coordinate exact box requirements with A/V system contractor. A/V system contractor is required to provide designation of A/V system cable infrastructure requirements, including cable types, sizes, and routing, for sound and video systems.
- D. Conduit: EMT, or equivalent, per NEC code. All exposed cabling to be in conduit, except as specifically allowed by Engineer. Any exposed cabling must meet NEC codes for CMR and CMP ratings as required and must be neatly and securely attached to the structure, using approved means and methods.
- E. Floor Boxes for A/V Systems:
 - 1. FSR FL-500P 4" deep. Provide 1/4" beveled flange in aluminum finish Quantities as shown on the A/V Drawings.
- F. Outlets, Speaker Outlets, and Junction Boxes:
 - 1. Single and double gang A/V system boxes; 4" square, 3-1/2" deep with single and double gang plaster rings.
 - 2. Three gang and larger back boxes to be determined by A/V system design and A/V system subcontractor and as shown on the Drawings.
 - 3. Junction boxes other than above to be sized according to requirements of A/V subcontractor and as shown on the Drawings.
 - 4. Coordinate these requirements with A/V system Contractor. Include rough-in boxes as required to accommodate all wiring, racks, interfaces and devices on A/V system drawings and in A/V system Specifications.
- G. Speaker Back Boxes:
 - 1. Description: Square metal enclose for ceiling speakers as specified in the A/V system Specification.
 - 2. Support back box from structural ceiling and insert into appropriate cutout of suspended ceiling tile.

3. Coordinate final speaker back box placement with Architect in conjunction with other ceiling elements including but not limited to lights and ductwork. Bring to the attention of the Architect any deviations of speaker placement from those shown on the Drawings.
- H. Pull Wire: shall be plastic, having not less than 200 pound tensile strength. All Alternate A/V system raceways shall have pull strings installed.
- I. Plates: Provide blank steel cover plates for all A/V system boxes as required.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Except as otherwise specified in this Section, comply with other Sections of Division 26 for installation of A/V system infrastructure.
- B. Provide and install accessories as required to form complete systems for raceway, grounding, and branch power circuitry.
- C. Locations of outlet boxes, speakers, racks etc. shown on the Drawings are approximate. Refer to Architectural Drawings, including wall elevations, reflected ceiling plans, dimensioned floor plans and details for exact locations. Verify exact location of all devices, whether shown on the Architectural Drawings or not, with Architect prior to rough-in.
- D. Install A/V system raceways to comply with NEC chapters 1-3, regardless of class of wiring to be installed.
- E. Separation:
 1. Maintain 24 inch minimum separation from conduits and wiring of power, lighting and class 1 signaling circuits.
 2. Maintain 48 inch minimum separation from dimmed lighting circuits.
 3. Separation of the above adjacent runs of less than 50 feet may be reduced by one half of the above distances (12 inches and 24 inches respectively).
 4. Where conduits run adjacent for less than 50 feet or where conduits cross at right angles, separation of 2 inches may be used.
- F. Do not combine speaker level conduits with line or microphone level conduits.
- G. Clearly document the exact locations of bull boxes and provide documentation to the A/V system Contractor and with the project Record Drawings.
- H. Install speaker back boxes exactly centered on ceiling tile or building ceiling element. Mount boxes flush and plumb. Caulk speaker boxes around ceiling tile or GWB to form an air tight seal. Do not support speaker enclosures with lay-in tiles or GWB. Attach boxes to building structural elements so that no perceptible sag occurs with speaker in place. Speaker weight is approximately 15 pounds.

- I. Identify each conduit and other raceway at each end with purpose and destination (e.g. "Sound Speakers to Room 301"). Label each outlet box, back box, and pull box with purpose and device. Provide clear and permanent labeling.
- J. Seal all exterior penetrations.

END OF SECTION 270528

SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

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

1.3 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M.

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. Allied Tube & Conduit.
 - 2. Cooper B-Line, Inc.; a division of Cooper Industries.
 - 3. ERICO International Corporation.
 - 4. GS Metals Corp.
 - 5. Thomas & Betts Corporation.
 - 6. Unistrut; Tyco International, Ltd.
 - 7. Wesanco, Inc.

2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in division 01, to design hanger and support system.

- B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."
 - 2. Component Importance Factor: 1.0.
- C. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame Rating: Class 1.
 - 2. Self-extinguishing according to ASTM D 635.

2.3 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch- (10-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c. in at least one surface.
 - 1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 2. Material for Channel, Fittings, and Accessories: Galvanized steel.
 - 3. Channel Width: Selected for applicable load criteria.
 - 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 5. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
 - 6. Channel Dimensions: Selected for applicable load criteria.
- B. Conduit and Cable Support Devices: Steel clamps, hangers, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored communications conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be made of malleable iron.
- D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 2. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.

3. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:
 1. NECA 1.
 2. NECA 101
- B. Comply with requirements for pathways specified in division 27.
- C. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMTs, IMCs, and RMCs as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Raceway Support Methods: In addition to methods described in NECA 1, EMT may be supported by openings through structure members, according to NFPA 70.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components, so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten communications items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 1. To Wood: Fasten with lag screws or through bolts.

2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Use approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Use expansion anchor fasteners.
 5. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.
 6. To Light Steel: Sheet metal screws.
 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that comply with seismic-restraint strength and anchorage requirements.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 PAINTING

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

END OF SECTION 270529

SECTION 270536 - CABLE TRAYS FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of cable tray.
 - 1. Include data indicating dimensions and finishes for each type of cable tray indicated.
- B. Shop Drawings: For each type of cable tray.
 - 1. Show fabrication and installation details of cable trays, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
- C. Delegated-Design Submittal: For seismic restraints.
 - 1. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
 - 2. Design Calculations: Calculate requirements for selecting seismic restraints.
 - 3. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

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. 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. Seismic Qualification Data: Certificates, for cable trays, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Division 01 to design cable tray supports and seismic bracing.
- B. Seismic Performance: Cable trays and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the cable trays will remain in place without separation of any parts when subjected to the seismic forces specified."
 2. Component Importance Factor: 1.5.
- C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes in cable tray installed outdoors.
 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 GENERAL REQUIREMENTS FOR CABLE TRAYS

- A. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 1. Source Limitations: Obtain cable trays and components from single manufacturer.
- B. Structural Performance: See articles for individual cable tray types for specific values for the following parameters:
 1. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 2. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 3. Load and Safety Factors: Applicable to both side rails and rung capacities.

2.3 LADDER CABLE TRAY

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

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Chalfant Manufacturing Company.
3. Cooper B-Line, Inc.
4. MP Husky.
5. Chatsworth Products, Inc.

B. Description:

1. Configuration: Two longitudinal side rails with transverse rungs swaged or welded to side rails, complying with NEMA VE 1.
 - a. Include junction splice kit, butt splice kit, and additional materials to comply with configuration shown on Drawings.
2. Width: 12 inches (300 mm) unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches (100 mm).
4. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
5. Rung Spacing: 9 inches (225 mm) o.c.
6. Radius-Fitting Rung Spacing: 9 inches (225 mm) at center of tray's width.
7. Minimum Cable-Bearing Surface for Rungs: 7/8-inch (22-mm) 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 (90-kg) concentrated load, when tested according to NEMA VE 1.
10. Fitting Minimum Radius: 18 inches (450 mm).
11. Class Designation: Comply with NEMA VE 1, Class 12B.
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.

C. Materials and Finishes:

1. Aluminum:
 - a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
 - b. Hardware: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.
 - c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.4 WIRE-BASKET CABLE TRAYS

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

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. Chalfant Manufacturing Company.
3. Cooper B-Line, Inc.
4. MP Husky.
5. Chatsworth Products, Inc.

B. Description:

1. Configuration: Wires are formed into a standard 2-by-4-inch wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along the entire length of section.
2. Width: 12 inches (300 mm) unless otherwise indicated on Drawings.
3. Minimum Usable Load Depth: 4 inches (100 mm).
4. Straight Section Lengths: 10 feet (3.0 m), except where shorter lengths are required to facilitate tray assembly.
5. Connector assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically join adjacent wires to splice sections together or to create horizontal fittings.
6. Connector Assembly capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.

C. Materials and Finishes:

1. Aluminum:
 - a. Materials: Alloy 6063-T6 according to ANSI H35.1/H 35.1M for extruded components, and Alloy 5052-H32 or Alloy 6061-T6 according to ANSI H35.1/H 35.1M for fabricated parts.
 - b. Hardware: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.
 - c. Hardware for Aluminum Cable Tray Used Outdoors: Stainless steel, Type 316, ASTM F 593 and ASTM F 594.

2.5 CABLE TRAY ACCESSORIES

- A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
- B. Barrier Strips: Same materials and finishes as for cable tray.
- C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.6 WARNING SIGNS

- A. Comply with requirements for identification in Division 26.
- B. Lettering: 1-1/2-inch- (40-mm-) high, black letters on yellow background with legend "Warning! Not To Be Used as Walkway, Ladder, or Support for Ladders or Personnel."

2.7 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect cable trays according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

- A. Install cable trays according to NEMA VE 2.
- B. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
- C. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
- D. Remove burrs and sharp edges from cable trays.
- E. Join aluminum cable tray with splice plates; use four square neck-carriage bolts and locknuts.
- F. Fasten cable tray supports to building structure and install seismic restraints.
- G. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
- H. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
- I. Support bus assembly to prevent twisting from eccentric loading.
- J. Install center-hung supports for single-rail trays designed for 60 versus 40 percent eccentric loading condition, with a safety factor of 3.
- K. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
- L. Support trapeze hangers for wire-basket trays with 3/8-inch- (10-mm-) diameter rods.

- M. 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.
- N. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
- O. Make changes in direction and elevation using manufacturer's recommended fittings.
- P. Make cable tray connections using manufacturer's recommended fittings.
- Q. Seal penetrations through fire and smoke barriers.
- R. Install capped metal sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
- S. Install cable trays with enough workspace to permit access for installing cables.
- T. 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.
- U. Install permanent covers, if used, after installing cable. Install cover clamps according to NEMA VE 2.
- V. Clamp covers on cable trays installed outdoors with heavy-duty clamps.
- W. 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 division 27.
- B. Cable trays shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
- C. Cable trays with single-conductor power conductors shall be bonded together with a grounding conductor run in the tray along with the power conductors and bonded to the tray at 72-inch (1800-mm) 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."

3.3 CABLE INSTALLATION

- A. Install cables only when each cable tray run has been completed and inspected.
- B. Fasten cables on horizontal runs with cable clamps or cable ties according to NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
- C. Fasten cables on vertical runs to cable trays every 18 inches (450 mm).
- 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 (1800 mm).
- E. Tie MI cables down every 36 inches where required to provide a 2-hour fire rating and every 72 inches everywhere.
- F. In existing construction, remove inactive or dead cables from cable trays.

3.4 CONNECTIONS

- A. Remove paint from all connection points before making connections. Repair paint after the connections are completed.
- B. Connect pathways to cable trays according to requirements in NEMA VE 2 and NEMA FG 1.

3.5 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 retorque in suspect areas.
 - 7. Check for improperly sized or installed bonding jumpers.

8. Check for missing, incorrect, or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
9. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable trays. Test entire cable tray system for continuity. Maximum allowable resistance is 1 ohm.

B. Prepare test and inspection reports.

3.6 PROTECTION

A. Protect installed cable trays and cables.

1. Install temporary protection for cables in open trays to safeguard exposed cables against falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials and shall remain in place until the risk of damage is over.
2. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
3. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.

END OF SECTION 270536

SECTION 270544 - SLEEVES AND SLEEVE SEALS FOR COMMUNICATIONS PATHWAYS AND
CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.
- F. Sleeves for Rectangular Openings:
 - 1. Material: Galvanized-steel sheet.
 - 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).

- b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.

- 1. Available Manufacturers:

- 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. Available Manufacturers:

- 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 (34.5-MPa), 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.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking 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 pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in division 07.
 - 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 (6.4-mm) annular clear space between sleeve and pathway 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 (50 mm) 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 pathways 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 (25-mm) 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 (25-mm) annular clear space between pathway 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 pathway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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 270544

SECTION 270553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for communications identification products.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and TIA 606-B.
- B. Comply with ANSI Z535.4 for safety signs and labels.
- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 - 1. Black letters on a white field.

2.3 LABELS

- A. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- (0.08-mm-) 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: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- B. Self-Adhesive Labels: Vinyl, thermal, transfer-printed, 3-mil- (0.08-mm-) thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches (37 by 150 mm) for raceway and conductors.
 - b. 3-1/2 by 5 inches (76 by 127 mm) for equipment.
 - c. As required by authorities having jurisdiction.

2.4 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground communications utility lines.
 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 3. Tape material and ink shall be chemically inert and not subject to degradation when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- B. Color and Printing:
1. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, and ANSI Z535.4.
 2. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL-FIBER CABLE".
- C. Tag: Type I:
1. Pigmented polyolefin, bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 2. Width: 3 inches (75 mm).
 3. Thickness: 4 mils (0.1 mm).
 4. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
 5. Tensile according to ASTM D 882: 30 lbf (133.4 N) and 2500 psi (17.2 MPa).

2.5 SIGNS

- A. Baked-Enamel Signs:
1. Preprinted aluminum signs, high-intensity reflective, punched or drilled for fasteners, with colors, legend, and size required for application.
 2. 1/4-inch (6.4-mm) grommets in corners for mounting.

3. Nominal Size: 7 by 10 inches (180 by 250 mm).

B. Laminated-Acrylic or Melamine-Plastic Signs:

1. Engraved legend.
2. Thickness:
 - a. For signs up to 20 sq. in. (129 sq. cm), minimum 1/16 inch (1.6 mm) thick.
 - b. For signs larger than 20 sq. in. (129 sq. cm), 1/8 inch (3.2 mm) thick.
 - c. Engraved legend with white letters on a dark gray background.
 - d. Self-adhesive.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 CABLE TIES

A. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black, except where used for color-coding.

B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 12,000 psi (82.7 MPa).
3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
4. Color: Black.

C. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.

1. Minimum Width: 3/16 inch (5 mm).
2. Tensile Strength at 73 deg F (23 deg C) according to ASTM D 638: 7000 psi (48.2 MPa).
3. UL 94 Flame Rating: 94V-0.
4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
5. Color: Black.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- H. Self-Adhesive Wraparound Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches (150 mm) from cable end.
- I. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
- J. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.
2. Install underground-line warning tape for direct-buried cables and cables in raceways.

K. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- C. Accessible Fittings for Raceways and Cables within Buildings: Identify covers of each junction and pull box with self-adhesive labels containing wiring system legend.
 1. System legends shall be as follows:
 - a. Telecommunications.
- D. Faceplates: Label individual faceplates with self-adhesive labels. Place label at top of faceplate. Each faceplate shall be labeled with its individual, sequential designation, numbered clockwise when entering room from primary egress, composed of the following, in the order listed:
 1. Wiring closet designation.
 2. Colon.
 3. Faceplate number.
- 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 in each rack, starting at top and working down, with self-adhesive labels.
 3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
 - a. Room number being served.
 - b. Colon.
 - c. Faceplate number.

- F. Backbone Cables: Label each cable with a self-adhesive wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.
- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:
 - 1. Room number.
 - 2. Colon.
 - 3. Faceplate number.
- H. Locations of Underground Lines: Underground-line warning tape for copper, coaxial, hybrid copper/fiber, and optical-fiber cable.
- I. Instructional Signs: Self-adhesive labels.
- J. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive labels.
 - 1. Apply to exterior of door, cover, or other access.
- K. Equipment Identification Labels:
 - 1. Indoor Equipment: Self-adhesive label.
 - 2. Outdoor Equipment: Laminated-acrylic or melamine-plastic sign and Stenciled legend 4 inches (100 mm) high.
 - 3. Equipment to Be Labeled:
 - a. Communications cabinets.
 - b. Uninterruptible power supplies.
 - c. Computer room air conditioners.
 - d. Fire-alarm and suppression equipment.
 - e. Egress points.
 - f. Power distribution components.

END OF SECTION 270553

SECTION 271100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. Access Provider: An operator that provides a circuit path or facility between the service provider and user. An access provider can also be a service provider.
- B. BICSI: Building Industry Consulting Service International.
- C. RCDD: Registered communications distribution designer.
- D. Service Provider: The operator of a telecommunications transmission service delivered through access provider facilities.
- E. TGB: Telecommunications grounding bus bar.
- F. TMGB: Telecommunications main grounding bus bar.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 - 3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- B. Seismic Qualification Data: Certificates, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 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 RCDD.
 - 2. Installation Supervision: Installation shall be under direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm) with the following:
 - 1. A/B grade
 - 2. Finished with two (2) coats of white fire retardant paint.

3. 3/4 by 48 by 96 inch sheets, mounted vertically, with bottom of sheet mounted at 6" above finished floor.
4. Cover all walls within MDF/IDF rooms unless noted otherwise on drawings.
5. Comply with requirements for plywood backing panels specified in Division 01.

2.3 BOXES, ENCLOSURES, AND CABINETS

A. Available Manufacturers:

1. Chatsworth Products Inc. (CPI).

B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets shall be listed and labeled for intended location and use.

1. Distribution frames: Freestanding, modular-steel units designed for telecommunication terminal support and coordinated with dimensions of units to be supported.
2. Module dimensions: Width compatible with EIA 310-D standard, 19-inch panel mounting.
3. Finish: Black, baked-polyester powder coat.

C. Floor-Mounted Racks, Open, Two Post: Modular-type, steel or aluminum construction.

1. Chatsworth 55053-703, or equivalent with the following:
 - a. Seven feet tall, 19-inch panel mounting, 6-inch side rails.
 - b. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug.
 - c. Baked-polyester powder coat black finish.

D. Cable Management for Equipment Frames:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.

B. Chatsworth 12851-706, or approved equivalent with the following:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Vertical rack mounting, with integral flanges.
3. Housing: Metal.

4. Minimum of twenty (20), 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
5. Mounted to the rear rail of the rack.
6. LED indicator lights for power and protection status.
7. LED indicator lights for reverse polarity and open outlet ground.
8. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
9. Cord connected with 15-foot (4.5-m) line cord.
10. Rocker-type on-off switch, illuminated when in on position.
11. Surge Protection: UL 1449, Type 3.
 - a. Maximum Surge Current, Line to Neutral: 27 kA.
 - b. Protection modes shall be line to neutral, line to ground, and neutral to ground.
 - c. UL 1449 Voltage Protection Rating for line to neutral and line to ground shall be 600 V and 500 V for neutral to ground.

2.5 GROUNDING

- A. Comply with requirements in division 27 for grounding conductors and connectors.
- B. Telecommunications Main Bus Bar:
 1. Connectors: Mechanical type, cast silicon bronze, solderless compression or exothermic-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
 3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.6 IDENTIFICATION

- A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Refer to division 26, 27, and 28 for additional identification information.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

- A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
- B. Comply with requirements in division 27 for materials and installation requirements for underground pathways.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI's "Telecommunications Distribution Methods Manual" for layout of communications equipment spaces.
- C. Comply with BICSI's "Information Technology Systems Installation Methods Manual" for installation of equipment in communications equipment spaces.
- D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- E. Coordinate layout and installation of communications equipment in tracks and in room. Coordinate service entrance configuration with service provider.
 - 1. Meet jointly with systems providers, equipment suppliers, and Owner to exchange information and agree on details of equipment configurations and installation interfaces.
 - 2. Record agreements reached in meetings and distribute them to other participants.
 - 3. Adjust configurations and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize configurations and space requirements of communications equipment.
 - 4. Adjust configurations and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in equipment room.
- F. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.
- G. Backboards:
 - 1. Install from 6 inches (150 mm) to 8 feet, 6 inches (2588 mm) above finished floor. If plywood is fire rated, ensure that fire-rating stamp is visible after installation.
 - 2. Paint all sides of backboard with two coats of paint.
 - 3. Comply with requirements for backboard installation in BICSI's "Information Technology Systems Installation Methods Manual" and TIA-569-D.

3.3 SLEEVE AND SLEEVE SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in division 27.

3.4 FIRESTOPPING

- A. Comply with requirements in division 07.
- B. Comply with TIA-569-D, Annex A, "Firestopping."

- C. Comply with BICSI's "Information Technology Systems Installation Methods Manual,"
"Firestopping Practices" Ch.

END OF SECTION 271100

SECTION 271500 – COMMUNICATIONS 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 ERATE FUNDING REQUIREMENTS

- A. All service provider's sub-contractors must have a Service Provider Identification Number [SPIN] and be in compliance with all FCC/USAC rules and regulations including but not limited to filing yearly the service provider FCC Form 473; certifying that the service provider have complied with E-Rate program rules.

1.3 COMPLIANCE

- A. Work and materials shall conform in every detail to the rules and requirements on the National Fire Protection Association and present manufacturing standards. Materials shall be listed by UL, and shall bear the UL label.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Telecommunication Contractor must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of shop drawings shall be under the direct supervision of a BICSI as RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of a BICSI who shall be present at all times when Work of this Section is performed at project site.
 - 3. Field Inspector: Currently registered by a BICSI as RCDD to perform the on-site inspection.
- 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. Telecommunications Pathways and Spaces: Comply with ANSI/TIA-569-D.
- D. Grounding: Comply with ANSI/TIA-607-B.

1.5 HORIZONTAL CABLING DESCRIPTION

- A. This section describes the products and execution requirements relating to furnishing and installation of Telecommunications Cabling and Termination components as part of a Structured Cabling System. Inter-building, Vertical (Backbone), and Horizontal (Station) cabling comprised of Copper, and Fiber Optic Cabling are covered under this document.
 - 1. ANSI/TIA-568-C.1 requires that a minimum of two telecommunications outlet/connectors 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 outlet/connector.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
 - 4. Splitters shall not be installed as part of the optical fiber cabling.

1.6 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in ANSI/TIA-568-C.1 when tested according to test procedures of this standard.
- B. UTP Performance: Balanced twisted-pair telecommunications cabling and component backbone cabling system shall comply with transmission standards in ANSI/TIA-568-C.2 when tested according to test procedures of this standard.
- C. OFC Performance: Optical Fiber cabling and component backbone cabling system shall comply with transmission standards in ANSI/TIA-568-C.3 when tested according to test procedures of this standard.

1.7 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.

1.8 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For RCDD, Installer, installation supervisor, and field inspector.

- B. Product Certificates: For each type of product.

1.9 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices and connectors to include in maintenance manuals.
- B. As-Built drawings noting final locations and cabling routing.

1.10 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. Connecting Blocks: One of each type.
 - 2. Faceplates: One of each type.
 - 3. Jacks: Ten of each type.
 - 4. Multiuser Telecommunications Outlet Assemblies: One of each type.
 - 5. Patch-Panel Units: One of each type.
 - 6. Plugs: Ten of each type.

1.11 COMPLIANCE

- A. The Telecommunications Contractor shall be a firm which is regularly and professionally engaged in the business of the installation and testing of the specified telecommunications system and equipment. The Telecommunications Contractor shall be an approved Certified Installer and Integrator of the manufacturer provided. The Telecommunications Contractor shall register the project and submit test data for approval, per the requirements of the manufacturer provided certification program guidelines.
- B. The Telecommunications Contractor shall have at a minimum one (1) Certified Installer trained and certified by manufacturer to ensure the proper installation and testing of copper and fiber optics structured cabling systems. The Contractor shall submit evidence of compliance with this requirement prior to having the individuals start any work on the product.
- C. Work and materials shall conform in every detail to the rules and requirements on the National Fire Protection Association and present manufacturing standards. Materials shall be listed by UL, and shall bear the UL label.
- D. Other applicable standards are as follows: Refer to Division 27 for reference standards that apply to this section.
- E. The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the installation and testing of the specified telecommunications system and equipment.
- F. The telecommunications contractor shall have a minimum of half (50%) of the installers trained to ensure the proper installation and testing of copper and fiber optics structured cabling

systems. The Contractor shall submit evidence of compliance with this requirement prior to having the individuals start any work on the product.

1.12 PRECONSTRUCTION MEETING

- A. All individuals who will be installers and terminators of data cables shall be required to attend a preconstruction meeting relating to the installation of the systems. Individuals who do not attend the meeting will not be allowed to install, terminate or test communications cables on the project

1.13 WARRANTY

- A. An extended project warranty and system assurance warranty for this structured cabling system shall be provided and consist of the following:
 - 1. Extended Product Warranty: The extended product warranty shall support the current and approved applications for which it was initially designed. Such applications must utilize the current ANSI/TIA-568-C specifications that define component, link, channel and backbone performance for structured cabling systems.
 - 2. Application Assurance: Applications assurance for the horizontal and backbone systems specifications of applications that have been designed to operate over the structured cabling system (cable and connectivity interface hardware). These components shall meet or exceed all performance and testing requirements of the current and approved ANSI/TIA-568C Telecommunications Standard at the time of installation.
 - 3. System Certification: Upon successful completion of the installation and subsequent inspection, the customer shall be provided with a numbered certificate from the manufacturing company registering the installation.
 - 4. The Extended Product Warranty and the System Assurance shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s).
 - 5. The warranty shall extend from the date of substantial completion to the longer of twenty five years or the length of the standard warranty offered by the manufacturer.
 - 6. The warranty shall be extended to the Owner via the manufacturer through a single point of contract and shall be fully backed by the manufacturer. Prior to starting work, the Contractor shall submit to the Owner written proof of qualification to offer the manufacturer's warranty.
 - 7. The Telecommunications Contractor shall submit after installation all documentation to support the warranty in accordance with the manufacturer's warranty requirements, and to apply for said warranty on behalf of the District. A valid warranty claim will cover the components and labor associated with the repair/replacement of any failed link within the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURER:

- 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. SYSTIMAX or equal by:
 - a. UNIPRISE
 - b. PANDUIT.

2.2 PATHWAYS

- A. General Requirements: Comply with ANSI/TIA-569-D.
- B. Only devices and cable tray have been shown on the drawings. The Telecommunications Contractor is responsible to provide a complete design-build pathway system. The Telecommunications shop drawings shall contain a fully-designed pathway system.
- C. Cable Support: NRTL labeled for support of Category 6A cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 2. Lacing bars, spools, junction hooks and D-rings.
 - 3. Straps and other devices.
- D. Cable Trays: Comply with the requirements of Division 26.
- E. Conduit and Boxes: Provide single gang plaster ring on a 4-11/16" square, 2-1/8" deep box for each outlet unless noted otherwise. Comply with requirements in Division 26.
- F. Cable Runway: 12" wide cable runway with grey finish and 12" rung spacing. Provide supports and all required fittings, including drop outs at racks. Install around the perimeter and above equipment racks in the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF). Chatsworth #10250-X12.
- G. Pull String: Provide nylon pull string for all empty raceways.

2.3 VOICE BACKBONE CABLING

- A. The voice Backbone Cable shall link the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF) serving the building.
- B. The voice Backbone Cable shall incorporate 24-AWG solid copper conductors, plenum-rated, and be defined by the ANSI/TIA-568-C.2 Commercial Building Telecommunications Cabling Standard and shall conform to Category 3 performance specifications.

- C. When cables of larger than 25 pairs are required, the core shall be assembled into 25-pair sub-units, each color coded.
- D. Cable shall be available in 25, 50 and 100 pair counts.
- E. UL listed for fire safety.

2.4 RACK-MOUNTED FIBER OPTIC PATCHPANELS

- A. Provide rack mounted modular enclosure units complete with duplex LC connector couplings. The Patch Panels enclosure shall provide for strain relief of incoming cables and incorporate radius control mechanisms to limit bending of the fiber to therecommended minimums.
- B. Patch Panels shall be installed on equipment racks as specified herein and used for termination of all fiber optic cables in the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF). Provide sufficient patch panels in each equipment rack to terminate all fibers.

2.5 FIBER OPTIC CONNECTORS

- A. Provide field installable duplex LC style multimode connectors to terminate optical fiber cables. Insertion loss not more than .75dB.
- B. The connector shall be capable of mounting on either 2.4mm buffered fiber to 3.0mm diameter jacketed cables. The connector shall meet EIA and IEC standards for repeatability.
- C. The attenuation per mated pair shall not exceed 0.5-db (Individual); 0.3-db(average).

2.6 MULTIMODE FIBER OPTIC CABLING

- A. Premise Distribution Optical Cable.
 - 1. Premise Fiber Optic cabling shall be installed between the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF) and shall consist of, plenum rated, UL listed Type OFNP; twelve (12) 50/125-micron fibers Laser Optimized each with a color coded PVC buffer.
 - 2. Graded-Index optical fiber wave-guide with nominal 50/125 um-core/cladding diameter
 - 3. Maximum attenuation loss shall be 3.50 db/km at 850 nm and 1.5 db/km at 1300 nm.
 - 4. Minimum bandwidth shall be 1500 MHz-km at 850 nm and 500 MH-km at 1300 nm.
 - 5. Cable shall be reinforced with Aramid yarn and contain no metallic elements.
- B. Patch Cords: Factory-made, dual-fiber cables.
- C. Cable running underground shall be suitable for direct burial.
- D. Site CCTV Cameras: Indoor/Outdoor Plenum rated (2) pair 50/125 micron fiber optic cable.

2.7 CATEGORY 6A MODULAR PATCH PANEL

- A. Provide Category 6A non keyed RJ45 modular to 110 printed circuit board style Patch Panels. The largest Patch Panel configuration shall not exceed 48 ports.
- B. The Patch Panel as a system (including jack, cable interface and intermediate components) must maintain Category 6A performance per the referenced ANSI/TIA standards.
- C. Patch Panels shall incorporate cable support and or strain relief mechanisms to secure the horizontal cables at the termination block to insure that the minimum bend radius specifications are adhered to.
- D. Patch Panels shall be installed on equipment racks as specified herein and used for termination of all horizontal station cables at the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF). Provide one port for each jack on each outlet plus a minimum of 10% spare ports.

2.8 HORIZONTAL CABLING

- A. High Speed Cables (Category 6: UTP, 4 Pair).
 - 1. Horizontal cables shall be extended between the work area location and its associated Intermediate Distribution Frame (IDF) or the Main Distribution Frame (MDF) and shall consist of 100 OHM Category 6, 4 pair, 23 gauge, Unshielded Twisted Pair (UTP) cable.
 - 2. The 4 pair balanced twisted pair Category 6A, UTP cable shall be UL Listed Type CMP (plenum) certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.
 - 3. All 4 pair Category 6 cables shall conform to ANSI/TIA-568-C.2 Balanced Twisted- Pair Telecommunications Cabling and Components Standards, and ANSI/TIA-568- B.2-1 Category 6A requirements.
 - 4. UL or ETL Verified for Category 6 Electrical Performance.
- B. Patch Cords: Factory-made, four-pair cables in 36-inch and 48-inch lengths; terminated with eight-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
 - 2. Patch cords shall have color-coded boots for circuit identification.
- C. High Speed Cables (Category 6A: UTP, 4 Pair).
 - 1. Horizontal cables shall be extended between the work area location and its associated Intermediate Distribution Frame (IDF) or the Main Distribution Frame (MDF) and shall consist of 100 OHM Category 6A, 4 pair, 23 gauge, Unshielded Twisted Pair (UTP) cable.
 - 2. The 4 pair balanced twisted pair Category 6A, UTP cable shall be UL Listed Type CMP (plenum) certified to meet transmission characteristics of Category 6A cable at frequencies up to 500MHz.

3. All 4 pair Category 6A cables shall conform to ANSI/TIA-568-C.2 Balanced Twisted-Pair Telecommunications Cabling and Components Standards, and ANSI/TIA-568- B.2-1 Category 6A requirements.
4. UL or ETL Verified for Category 6A Electrical Performance.

D. Patch Cords: Owner furnished, contractor installed for all colors.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6A performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.9 WORK AREA OUTLETS

A. Horizontal cables shall be terminated at their designated work area location in the connector types described in the subsections below. Included are modular telecommunications jacks. These connector assemblies shall snap into a faceplate.

B. Confirm all cable colors with District prior to ordering.

1. Telecommunications: Blue.
 - a. Patch cable: Grey
2. Fire Alarm: Red
 - a. Patch cable: Red
3. HVAC: Black
 - a. Patch cable: Black
4. Other mechanical systems: Black
 - a. Patch cable: Purple
5. Access Points: Blue
 - a. Patch cable: White
6. VOIP: Blue
 - a. Patch cable: Green
7. General Lighting: Green
 - a. Patch cable: Blue
8. Specialty (production) Lighting: Orange

- a. Patch cable: Orange
- 9. AV Systems: Orange
 - a. Patch cable: Orange
- 10. Paging: Pink
 - a. Patch cable: Pink
- 11. Security IP System: Pink
 - a. Patch cable: Pink
- 12. Other systems: Grey
 - a. Patch cable: Grey
- C. Plugs and Plug Assemblies:
 - 1. Male; eight position; color-coded modular telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Standard: Comply with TIA-568-C.2.
 - 3. Marked to indicate transmission performance.
- D. Jacks and Jack Assemblies:
 - 1. Female; eight position; modular; fixed telecommunications connector designed for termination of a single four-pair, 100-ohm, unshielded or shielded twisted pair cable.
 - 2. Designed to snap-in to a patch panel or faceplate.
 - 3. Standard: Comply with TIA-568-C.2.
 - 4. Standard Duplex locations to have one Orange and one Ivory jack.
 - 5. Marked to indicate transmission performance.
- E. Faceplate:
 - 1. Two port, vertical single gang faceplates designed to mount to single gang wall boxes.
 - 2. Faceplate: Coordinate color with Section 262726 "Wiring Devices."
 - 3. For use with snap-in jacks accommodating any combination of twisted pair, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, positioning the cord at a 45-degree angle.
- F. Legend:
 - 1. Machine printed, in the field, using adhesive-tape label.
 - 2. Snap-in, clear-label covers and machine-printed paper inserts.
- G. All standard workstation outlets shall be Cat 6 and all outlets for WAP shall be Cat 6A.

2.10 WIRELESS ACCESS POINT (WAP) ENCLOSURES

- A. Coordinate exact location and type of enclosure to use with the owner before installing.
- B. All CMU or solid wall construction shall have the following properties.
 - 1. Pressed steel, zinc coated with single plaster ring.
 - 2. 4 11/16 inches square, 2 1/8 inches deep.
- C. Approved Products: Thomas and Betts
 - 1. Type 1 Enclosure: Thomas and Betts Steel City 1 11/16" square box.
 - 2. 2 1/8" deep with single-gang mud ring for all CMU and solid wall vertical applications.

PART 3 - EXECUTION

3.1 GENERAL

- A. Optical Fiber and Copper Pair counts of the cables to be supplied are detailed on the Project Drawings. The Telecommunications Contractor shall furnish and install all cables, connectors and equipment as shown on the drawings and specified above. IT shall be noted that all cables shall be installed in continuous lengths from endpoint to endpoint. No splices shall be allowed unless noted otherwise.
- B. It is the Telecommunications Contractors responsibility to survey the site and include all necessary costs to perform the installation as specified.
- C. Cable installation shall be done in accordance with the cable manufacture's recommendations and ANSI/IEEE C2 standards. Recommended pulling tensions and bending radius shall not be exceeded.
- D. Should it be found by the Engineer, that the materials or any portion thereof, furnished and installed under this contract fail to comply with the specifications and drawings, with the respect or regard to the quality, amount of value of materials, it shall be rejected and replaced by the Telecommunications Contractor and all work distributed by changes necessitated in consequence of said defects or imperfections shall be made good at the Telecommunications Contractors expense.

3.2 INSTALLATION

- A. Raceways: Terminate raceways 6" above suspended ceilings horizontally and provide plastic bushing on all metal raceways. Provide each raceway with nylon pull string.
- B. Raceway Routing: Raceways, where required, shall be stubbed into nearest accessible ceiling space or crawl space. Coordinate with General Contractor and Architect to confirm spaces that are considered accessible.

C. Comply with NECA 1 and NECA/BICSI 568.

D. General Requirements for Cabling:

1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
3. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. MUTOA shall not be used as a cross-connect point.
6. Consolidation points may be used only for making a direct connection to equipment outlets:
 - a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
 - b. Locate consolidation points for twisted-pair cables at least 49 feet from communications equipment room.
7. 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.
8. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
12. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
13. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Raceway Installation

1. Comply with NECA 1.
2. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
3. Cable Trays: Comply with NEMA VE 2 and ANSI/TIA-569-D.
4. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
5. Separation from EMI Sources:
 - a. Comply with BICSI TDMM and ANSI/TIA-569-D for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2kVA: A minimum of five inches.
 - 2) Electrical Equipment Rating between 2 and 5kVA: A minimum of 12 inches.
 - 3) Electrical Equipment Rating More Than 5kVA: A minimum of 24 inches.
 - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2kVA: A minimum of 2-1/2 inches.
 - 2) Electrical Equipment Rating between 2 and 5kVA: A minimum of six inches.
 - 3) Electrical Equipment Rating More Than 5kVA: A minimum of 12 inches.
 - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - 1) Electrical Equipment Rating Less Than 2kVA: No requirement.
 - 2) Electrical Equipment Rating between 2 and 5kVA: A minimum of three inches.
 - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of six inches.
 - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
 - f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of five inches.

H. Voice Backbone Cabling:

1. At the Main Distribution Frame (MDF) all Voice Backbone Cables shall be terminated on a high density horizontal 110 style blocks. 25 Pair tie cables shall be installed from the 110 blocks to the voice patch panels located in rack #2.
2. At each Intermediate Distribution Frame (IDF) all Voice Backbone Cables shall be terminated on voice patch panels.
3. Horizontal Troughs incorporating split plastic distribution rings shall be provided by the Telecommunications Contractor to accommodate routing of jumpers. Troughs shall be positioned at the top of each column of termination blocks and between each 100- pair wiring block.
4. Termination of Voice Backbone Cabling shall be accomplished by utilizing five pair (e.g. C5-type) clips.

I. Fiber Optic Cabling:

1. Install fiber optic cables in continuous lengths from the Main Distribution Frame (MDF) to each Intermediate Distribution Frame (IDF) as specified on the drawings. No splices allowed.
2. Terminate fiber optic cables in rack mounted fiber optic patch panels in the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF) as specified on the drawings.
3. Limit cable bending radius to 20 times the diameter during installation, and 10 times the diameter after installation.
4. Label fiber optic cables every 10 feet with red or orange tags which read: "Caution - Fiber Optic Cable."

J. Horizontal Cabling:

1. Terminate horizontal station cabling on modular patch panels in the Main Distribution Frame (MDF) and each Intermediate Distribution Frame (IDF) as specified on the drawings.
2. The maximum station cable drop length shall not exceed 295-feet (90-meters) in order to meet the performance specifications. The Telecommunications Contractor is responsible for installing station cable in a fashion as to avoid unnecessarily long cable runs. Any area that cannot be reached within the above constraints should be identified and reported to the Engineer prior to installation. Changes to the plan shall be approved by the Engineer.
3. Arrangement of cables at the patch panels shall be in ascending order of outlet numbers.
4. Do not install cabling in conduit or sleeves without plastic bushings.
5. Do not bind cables tightly together with wraps. Wraps shall slip loosely around cable.
6. No more than 50 cables shall be installed in a single bundle.
7. Cables shall be free from tension at both ends. In cases where the cable must bear some stress, Kellom grips may be used to spread the strain over a longer length of cable.
8. Maintain twists in pairs of wire to within 1/2" of termination.
9. Installation shall meet industry standards for Category 6A installation.

K. Telecommunications Outlets:

1. Cables shall be dressed and terminated in accordance with the recommendations made in ANSI/TIA -568 documents.

2. Pair untwist at the termination shall not exceed .24 inches for Category 6A connecting hardware.
 3. Bend radius of the cable in the termination area shall not be less than four times the outside diameter of the cable.
 4. The cable jacket shall be maintained as close as possible to the termination point.
- L. Patch Cables: Patch cords shall be provided on-site 4 weeks prior to the first substantial completion for the entire project.
1. Quantities shall be verified prior to ordering and included in all submittals.
 2. Provide the following factory made fiber patch cords as part of this contract.
 - a. Each IDF: Provide (6) 1 meter jumpers.
 - b. MDF: Provide (30) 1 meter jumpers.
 3. Provide the following factory made patch cords as part of this contract:
 - a. Grey (Telecommunications):
 - 1) Provide 100 percent of Telecommunications jacks - 1 foot length.
 - 2) Provide 50 percent of Telecommunications jacks - 7 foot length.
 - 3) Provide 50 percent of Telecommunications jacks - 14 foot length.
 - b. White (WAPS):
 - 1) Provide 100 percent of WAP jacks - 1 foot length.
 - 2) Provide 100 percent of WAP jacks - 3 foot length.
 - c. Pink (CCTV):
 - 1) Provide 100 percent of CCTV Jacks - 1 foot length.
 - 2) Provide 100 percent of CCTV Jacks - 3 foot length.

3.3 GROUNDING

- A. Install grounding according to BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. Comply with ANSI/TIA-607-B.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least two-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 to building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

- E. At the Main Distribution Frame (MDF), Intermediate Distribution Frame (IDF), and at the Electrical Service Entry, a "Telecommunications Grounding Busbar (TGB) shall be provided and installed.
- F. Provide a ground terminal block at each equipment rack.
- G. Where multiple racks are installed in the same room, bond all racks together with a #6 stranded copper ground conductor.

3.4 FIRESTOPPING

- A. Comply with requirements in Division 07, "Penetration Firestopping."
- B. Comply with ANSI/TIA-569-D, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems."

3.5 IDENTIFICATION

- A. Refer to Division 27 for labeling requirements that apply to this section.

3.6 INSPECTION PROCEDURES

- A. The Owner will conduct periodic inspections of the work in progress. Inspections by the Owner in no way limit the Contractor's responsibility for compliance with the contract documents.
- B. The Owner reserves the right to hire an independent testing company to spot check the test results. If the results vary more than 10% from the results provided by the Contractor, the Contractor will be required to correct any deficiencies and retest the entire system at no additional cost to the project.

3.7 TERMINATIONS

- A. Terminate, test and label all copper and fiber optic cables.
- B. Terminations must be made by certified personnel in strict accordance with the connector manufacturer's installation procedure. As a condition of contract award, the Contractor must provide evidence that the personnel performing terminations are certified by the connector manufacturer.
- C. Fiber optic cables must be terminated such that the strength member of each cable is mechanically secured to the patch panel bracket or clamp so that any tension on the cable will not stress the individual fibers.

3.8 ACCEPTANCE TESTING PROCEDURES

A. General:

1. Provide a detailed test procedure for approval by the Owner prior to beginning testing. The Owner reserves the right to witness all testing.
2. Upon completion of all testing a certified test report shall be provided. The report shall include the following information as a minimum:
 - a. Copy of the approved test procedure.
 - b. Date(s) of test.
 - c. Individual(s) performing the test.
 - d. Make, model number and serial number of all test equipment.
 - e. Cable identification number and the associated test results.

B. The cabling must be installed and the final test reports delivered to the Owner two weeks prior to substantial completion. Test reports shall be bound in a separate volume of the O & M manual.

C. Prior to beginning any testing, the Contractor shall schedule a walk-through with the Owner and the Engineer to review the installation.

D. UTP Cabling: All UTP cabling will be certified to meet or exceed the specifications as set forth in ANSI/TIA-568C.2 for channels, permanent links, and horizontal cables. Certifications shall include the following parameters for each pair of each cable installed:

	Category 3	Category 6A
Channel Transmission Performance		
Wire Map	<input type="checkbox"/>	<input type="checkbox"/>
Length	<input type="checkbox"/>	<input type="checkbox"/>
Return Loss		<input type="checkbox"/>
Insertion Loss	<input type="checkbox"/>	<input type="checkbox"/>
NEXT	<input type="checkbox"/>	<input type="checkbox"/>
PSNEXT		<input type="checkbox"/>
	Category 3	Category 6A
ACRF		<input type="checkbox"/>
PSACRF		<input type="checkbox"/>

	Category 3	Category 6A
Propagation Delay	<input type="checkbox"/>	<input type="checkbox"/>
Propagation Delay Skew	<input type="checkbox"/>	<input type="checkbox"/>
PSANEXT		<input type="checkbox"/>
PSAACRF		<input type="checkbox"/>
Permanent Link Transmission Performance		
Return Loss		<input type="checkbox"/>
Insertion Loss	<input type="checkbox"/>	<input type="checkbox"/>
NEXT	<input type="checkbox"/>	<input type="checkbox"/>
PSNEXT		<input type="checkbox"/>

ACRF		<input type="checkbox"/>
PSACRF		<input type="checkbox"/>
Propagation Delay	<input type="checkbox"/>	<input type="checkbox"/>
Propagation Delay Skew	<input type="checkbox"/>	<input type="checkbox"/>
PSANEXT		<input type="checkbox"/>
PSAACRF		<input type="checkbox"/>
Horizontal Cable Transmission Performance		
Structural Return Loss	<input type="checkbox"/>	
Return Loss		<input type="checkbox"/>
Insertion Loss	<input type="checkbox"/>	<input type="checkbox"/>
NEXT	<input type="checkbox"/>	<input type="checkbox"/>
PSNEXT		<input type="checkbox"/>
ACRF		<input type="checkbox"/>
PSACRF		<input type="checkbox"/>
TCL		<input type="checkbox"/>
ELTCTL		<input type="checkbox"/>
Propagation Delay	<input type="checkbox"/>	<input type="checkbox"/>
Propagation Delay Skew	<input type="checkbox"/>	<input type="checkbox"/>
PSANEXT		<input type="checkbox"/>
PSAACRF		<input type="checkbox"/>

NEXT - Near-end crosstalk

PSNEXT - Power sum near-end crosstalk

ACRF - Attenuation to crosstalk ratio, far-end

PSACRF - Power sum attenuation to crosstalk ratio, far-end

TCL - Transverse conversion loss

ELTCTL - Equal level transverse conversion transfer loss

PSANEXT - Power sum alien near-end crosstalk

PSAACRF - Power sum attenuation to alien crosstalk ratio, far-end

- E. Provide a hard copy of test results. Each cable shall be identified by its jack number.
- F. Fiber Optic Cabling: Each fiber strand shall be tested in one direction utilizing and OTDR and in both directions utilizing a power meter for distance and attenuation. The attenuation per km is to be measured at 850 nm and 1300 nm wave lengths. The Contractor shall supply tracer recordings on each fiber strand containing the following information:
1. Fiber rating.
 2. Number of fiber strands.
 3. Transmit location.
 4. Receive location.
 5. Wave length (850 nm and 1300 nm).
 6. Attenuation.

3.9 AS-BUILT DRAWINGS

- A. Provide the following at the completion of the project:

1. As-built shop drawings (hard copy & disc) showing the as-built locations of all components, conduit runs and cables utilized.
2. One set of 18" x 24" floor plans (hard copy and disk) showing only the telephone/data outlets and associated jack numbers.

END OF SECTION 271500

SECTION 274116 - AUDIO VISUAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Work Specified Elsewhere:
 - 1. Section 115213
 - 2. Section 115200
 - 3. Section 270528 and associated Division 26 electrical, power and grounding requirements.

1.2 SUMMARY

- A. The system shall be called the "Audio Visual System" and the installer the "Audio Visual System Installer". The work in this Section includes but is not limited to:
 - 1. Audio mixers, equalizers, amplifiers, program sources, and other audio visual and signal processing equipment.
 - 2. Loudspeakers, custom enclosures, and speaker mounting or support hardware including speaker mounting frames and incidental support members.
 - 3. Equipment racks and millwork cabinets.
 - 4. Video displays, cameras, etc. and mounting or support hardware including mounting frames and incidental support members.
 - 5. Video systems, sources, routing, and switching.
 - 6. Control systems, equipment program development, and programming.
 - 7. Data network systems.
 - 8. Cables, connectors, plates, and wiring.
 - 9. Project detailing and coordination.
- B. Products furnished but not installed under this section:
 - 1. Loose items, microphones, remotes, etc.
- C. Products installed but not furnished under this section:
 - 1. Owner furnished equipment (OFE) as identified herein or on the Drawings.

1.3 REFERENCES

- A. Sound System Engineering (2nd Edition), Davis and Davis, Howard W. Sams 1987.

- B. Audio System – Design and Installation, Giddings, Howard W. Sams, 1990.
- C. Comply with all national, state and local regulations and the procedures and requirements of the local authorities. In the event of conflict between these specifications and the applicable regulations, the more stringent shall govern.
 - 1. Codes:
 - a. Oregon Building Code (OBC)
 - b. National Electric Code (NEC)
 - 2. Standards & Organizations:
 - a. National Fire Protection Association (NFPA)
 - b. Federal Communications Commission (FCC)
 - c. ANSI American National Standards Institute
 - d. ASA American Standards Association
 - e. ASTM American Society for Testing Materials
 - f. EIA/TIA Electronic Industries Association/Telecommunications Industries Association
 - g. ETL Electrical Testing Laboratories
 - h. ISO International Standards Organization
 - i. NEMA National Electrical Manufacturer's Association
 - j. UL Underwriter's Laboratories
 - k. ESTA Entertainment Services and Technology Association
- D. Equipment shall be provided in accordance with the related trade and regulatory guidelines including but not limited to UL, NEC, IEEE, and all manufacturer's recommendations and requirements. Contractor shall be responsible in the event that work under their control voids or jeopardizes manufacturers' warranties.
- E. Labor shall be provided in accordance with applicable labor regulations and practices.

1.4 QUALIFICATIONS

- A. All work to be performed by a licensed and bonded low-voltage specialty electrical contractor. Audio Visual System Installer shall have held a valid Washington State low-voltage contractor's license, under the current business name, for a period of not less than 5 years.
- B. All Audio Visual System equipment shall be installed by a single Audio Visual Installer, other than typical trade installed elements, such as conduit, back boxes, wire, cable, field devices, etc. All Audio Visual System equipment shall be furnished and installed by an authorized factory distributor. To ensure timely and competent direct factory support and service, the Audio Visual System Installer shall provide proof of direct factory franchise for all major specified Audio Visual System components, including but not limited to loud speakers, amplifiers, digital signal processing, video equipment, control system, projectors, and screens. The Audio Visual System Installer shall have a certified programmer on staff for the specified digital signal processing platforms and control systems and have been in the business of furnishing the specific product

lines for a minimum of 5 years. The Audio Visual System Installer shall have an ISF certified video calibration specialist on staff. Submit franchise and training certificates with bid.

- C. Pre-bid approval requests for installation of equipment other than that specified, except as noted herein as “no substitution”, must be received not less than 10 days prior to bid opening. Proposals must be accompanied by complete technical data including complete equipment list on Installer’s letterhead listing proposed alternate system components, compilation of manufacturers’ catalogs or specification sheets of submitted components, and functional block diagrams indicating system interconnection and functions. It is the sole responsibility of the Installer to prove equivalency to the satisfaction of the engineer including laboratory test data, fabrication techniques, installation, and testing procedures.
- D. Potential bidders submitting proposals for prior approval must provide, upon request, a working demonstration system for the Owner’s inspection prior to final acceptance to insure that the submitted components are equal to those specified in all functional aspects.
- E. Alternative proposals approved for bidding will be published by Addendum. Proposals not in compliance with the prior approval requirements and conditions set forth herein will not be considered.

1.5 CURRENT TECHNOLOGY:

- A. Only the most current hardware and software shall be provided. In no case will discontinued or superseded products be acceptable. If the manufacturer has developed and successfully released products that meet or exceed the criteria within this specification, the Contractor shall notify the Architect and submit the new product for review. If accepted, the products shall be provided at no additional cost to the Owner. Software upgrades and authorized support services for its proper integration into the system shall be provided at no cost to the Owner throughout the warranty period.
- B. In the event of known product defaults or recall, the Contractor shall immediately notify the Architect and make immediate arrangements for remedy.
- C. None of the stipulations herein shall be grounds for revision to the Project schedule.
- D. See related procedures under warranties in this section.

1.6 SUBMITTALS

- A. If permitted under Section 01— Submittal Procedures, all submittals shall be made in electronic format.
 - 1. Files shall be in .pdf format, and submitted via CD or DVD.
 - 2. Clearly indicate submittal number and description in the file name of the document.
 - 3. Each document shall be a separate file.
 - 4. Markups will be made electronically, and the submittal returned via electronic means.

- B. Submittals shall be made in a timely fashion so as to not affect the Project schedule, and shall allow for adequate time for review and resubmittal. Partial submittals will not be acceptable and will be returned without review.
- C. Submittals shall be reviewed and field dimensions verified prior to commencing acquisition for, and fabrication of the Work in this section. All services and parts of the work in this section shall be verified through the submittal process.
- D. Prior to commencing work on shop drawings, the contractor shall facilitate a meeting between the contractor and Architect and his consultant to “walk through” the AV systems.
- E. Conduit, Back boxes and Electrical Systems Verification Letter:
 - 1. Within 30 days of contract award, the AV contractor shall review all relevant information pertaining to the AV systems low-voltage conduit, back boxes, and line voltage electrical work to be performed by Division 26. A formal memo, outlining acceptance (or desired changes) of the contract drawing shall be provided. Failure to provide this memo indicates acceptance of, and liability for, the conduit, back boxes and electrical systems as indicated in the Drawings.
- F. Shop Drawings:
 - 1. Submit full-size (minimum 30" x 42") scaled shop drawings that show the following:
 - a. Installation requirements and mounting conditions.
 - b. Provide stamped structural drawings by a structural engineer licensed in the state in which the project takes place showing complete mounting details for all devices over 20 pounds.
 - c. Full system riser diagram(s) illustrating interconnection of system components, wiring requirements, back box sizes and any special installation considerations.
 - d. Block diagrams, showing equipment interconnection.
 - e. Internal DSP programming (may be submitted as software file, or in flowchart form on paper)
 - f. Equipment rack and patchpanel drawings.
 - g. Full-scale drawings of custom plates, including color schedule for each device.
 - h. Run sheets or field wiring drawings.
 - i. Equipment modification drawings, including statement of purpose for modification and agreement to provide full manufacturer warranty, if modifications cause a voided warranty.
 - j. Final schematic drawings of any custom circuitry.
 - k. Detailed equipment list, including quantity, manufacturer and model.
 - l. Detailed product drawings, as applicable to the project.
 - m. m. Copies of contract drawings will not be accepted as shop drawings, and will be returned without review.
 - 2. AV Control System Touchpanels:

- a. Provide an electronic file for approval of working touchpanel files. File shall be in a format that both consultant and Owner can use on any windows-based computer (with required software installation.)
 - b. Provide any required viewing software.
 - c. Touchpanel design subcontractor is responsible for design of touchpanel layouts, but shall be subject to consultant and Architect approval.
 - d. A separate file for each touchscreen shall be provided.
 3. Acceptance of any submitted data or shop drawings for material, equipment, apparatus, devices, arrangement and layout shall not relieve contractor from responsibility of furnishing same of proper dimensions and weight, capacities, sizes, quantity, and installation details to perform efficiently the requirements and intents of the systems design. Such acceptance shall not relieve the contractor from responsibility for error, omissions or inadequacies of any sort on submitted data or shop drawings.
- G. Product Data:
1. Submit a detailed equipment list, including manufacturer, model number, description and quantity for each item.
 2. Do not submit equipment cut sheets, except for custom or non-standard devices.
- H. Samples:
1. Submit samples for review. Samples may include, but are not limited to:
 - a. Connector, panel and cable assemblies
 - b. Panel finish samples
 - c. Custom switch, button or similar assemblies
- I. Record Documents: Submit record documents in accordance with Section 01.
1. At time of final acceptance, submit regulatory listings and certifications as required by prevailing building codes.
 2. Submit copies of "as-builts" including:
 - a. Shop drawings, product data, operations and instructions manuals for all products provided.
 - b. Equipment list, with manufacturer, model number, and serial number for all installed devices.
 - c. Electronic backup on Compact Disc of control systems or DSP systems programming.
 - d. Care and maintenance instructions, service line and online contacts.
 - e. Warranty documents.
 - f. Key list, showing the following for all keys in the system: device name and model number, system controlled, key model number or other replacement identifier, tech support number for equipment manufacture, and thumbnail picture of device.
- J. Submittal procedures and quantities are specified in Section 01— Submittal Procedures.

1.7 OPERATIONS AND MAINTENANCE MANUALS

- A. Provide 3 complete bound O&M manuals describing maintenance and operation of the system. Include descriptions and service data on all component parts. Manual shall also include the following:
1. Warranty statement indicating effective dates.
 2. Complete engineering data on all systems and equipment furnished, including operations and maintenance manuals, complete and accurate point to point wiring diagrams, cable labeling, and installed condition details of the system in its "as built" condition.
 3. Submit as-built drawings in native AutoCAD file format (2000 or later) on data CD's and in PDF document format.
 4. Step by step instructions on operational procedures, including power up and power down sequences, special operational guidelines, and standard preventative maintenance procedures. Permanently affix one copy to equipment rack.
 5. Provide up-compiled final programming versions of all custom programmed code-based systems, including but not limited to DSP's, routers, control systems, etc. Submit these files and associated data on standard computer data CD's.

1.8 SYSTEMS DESCRIPTION

- A. Provide complete and functioning Audio Visual Systems as shown on the Drawings and set forth in this Specification.
- B. Size high resolution cabling from AV sources and switches so that a maximum of .5dB loss occurs in any cable run. Video signals carried over Category UTP cable shall be compensated by the receiver equipment. No "compensation loop" coiling of cables to compensate for lengths is allowed. All UTP cabling shall conform to the Manufacturer's specifications for interconnection cabling of the devices being connected.
- C. Audio Visual System Installer is responsible for providing all mounting systems, blanks, vents, AC distribution, etc. for mill-worked equipment cabinets, racks, etc.
- D. Owner furnished equipment (OFE) is provided by Owner as shown on the drawings and specifications installed by Audio Visual System Installer. Audio Visual System Installer shall provide patch cords to Audio Visual System Installer provided equipment.
- E. Provide input connections, switching, etc. into systems for Owner provided PC's, laptops, VCR/DVD's, DVR's, and document cameras as shown on the Drawings and Specifications. All input plates are to be detailed by Installer and provided with appropriate industry standard connectors to meet the functional requirements of the system.
- F. Provide integrated system control and touch screens as shown. Audio Visual System Installer shall provide and program all control hardware and software to allow for Audio Visual System and Audio Visual device operations from control surfaces. Device operations to include, but not be limited to; screen controls, volume controls, switching and routing controls, projector controls, camera control and special functions as indicated. It is the Audio Visual System Installer's responsibility to detail and propose control surface functions and layouts. Provide sample screen shots and button labeling for approval as required in submittals section requirements above.

- G. Provide complete and functioning Audio Visual Systems as shown on the Drawings and set forth in this Specification.
- H. Size high resolution cabling from AV sources and switches so that a maximum of .5dB loss occurs in any cable run. Video signals carried over Category UTP cable shall be compensated by the receiver equipment. No "compensation loop" coiling of cables to compensate for lengths is allowed. All UTP cabling shall conform to the Manufacturer's specifications for interconnection cabling of the devices being connected.
- I. Audio Visual System Installer is responsible for providing all mounting systems, blanks, vents, AC distribution, etc. for mill-worked equipment cabinets, racks, etc.
- J. Owner furnished owner installed equipment (FOIO) is provided and installed by Owner as shown on the drawings and specifications.
- K. Provide input connections, switching, etc. into systems for Owner provided PC's, laptops, dVD's, DVR's, and document cameras as shown on the Drawings and Specifications. All input plates are to be detailed by Installer and provided with appropriate industry standard connectors to meet the functional requirements of the system.
- L. Each room shall function as a room system with a dedicated DSP and. However, audio and video can also be routed throughout the building for overflow and all hands routing. Centralized audio will be achieved via a BLU Link ring between BSS DSP devices. Centralized video will be achieved via SVSi video over IP using card based or stand-alone encoders and decoders. BLU-DAN's at the head end equipment location will serve as a bridge between BSS audio and SVSi audio utilizing AES67 compatibility. Audio sources will include in-room sources, live paging, pre-recorded paging messages and background music. Video sources will include any VGA or HDMI device connected to an SVSi encoder.
- M. Provide integrated system control and touch screens as shown. Audio Visual System Installer shall provide and program all control hardware and software to allow for Audio Visual System and Audio Visual device operations from control surfaces. Device operations to include, but not be limited to; screen controls, volume controls, switching and routing controls, projector controls, camera control and special functions as indicated. It is the Audio Visual System Installer's responsibility to detail and propose control surface functions and layouts. Provide sample screen shots and button labeling for approval as required in submittals section requirements above.
- N. The control system shall encompass all AMX, BSS, SVSi devices, audio amplifiers, CATV tuners, playback devices, displays, projectors and peripherals throughout the building via Network, RS-232 and IR connectivity. Processing will take place both on AMX NX masters and BSS DSP devices. User interfaces will be AMX touch panels throughout the building, typically 1 per room, with two admin locations.

1.9 WARRANTY

- A. Warranty shall provide coverage of material and product defects and assembly workmanship or installation for a period of two years following the date of acceptance by the Architect.

- B. Items under warranty shall be serviced to the satisfaction of the Owner with 14 days of notification to the Contractor.
- C. The Contractor shall bear all costs that arise as a result of the warranty claim, including, but not limited to, the use of temporary replacement components, additional Owner staffing or overtime, shipping, cancelled uses or performances.
- D. Activate all manufacturers' warranties in the name of the Owner, within one week of the date of acceptance.
- E. Provide two return visits following system acceptance to fine tune or repair any items requested by the Owner:
 - 1. 30-40 days following acceptance
 - 2. 1 year following acceptance

1.10 MAINTENANCE

- A. Provide maintenance stock of User-serviceable components within the system. Maintenance stock shall be packaged in weather resistant box labeled "spare parts for AV system" and turned over to the District at time of system commissioning.
- B. Maintenance stock shall include:
 - 1. Four fuses of each type in the system.
 - 2. Five connectors of each type in the system.
 - 3. Six spare keys of each type in the system.
 - 4. Components recommended by the manufacturer.
 - 5. Any non-standard tools required for Owner service.
 - 6. Four spare lamps for each type in the system

PART 2 - PRODUCTS

2.1 PRE-APPROVED SPECIALTY SUBCONTRACTORS

- A. The following AV systems contractors are pre-approved to complete the work in this section:

Avidex
13555 Bet-Red Road, Suite 226
Bellevue, WA 98005
800.798.0330

CompView Audio Visual
Attn: Deborah Klein
652 Industry Drive
Tukwila, WA 98188
206.805.3225

Delta AV
Attn: David Garlett
4040 SE International Way, #E106
Milwaukie, OR 97222
503.786.3733

Jaymarc-AV
Attn: Mark Bellesiles
2732 1st Ave S
Seattle, WA 98134
206.682.6111

- B. All other shall submit qualifications for approval. In order to qualify, the contractor shall submit the following information to the Architect for review:

1. Five years of financial reports.
2. List of personnel who will be working on this Project, including skills, experience, and accreditations.
3. List of union affiliations, contractor licenses, and other applicable trade certifications.
4. List of projects completed within the past 5 years, with references. Provide phone and/or e-mail addresses for reference contacts.
5. Proof that at least 5 jobs in the past 5 years have a minimum contract value equal to or greater than the project listed herein.
6. Proof of bonding and insurance.

2.2 SYSTEMS:

A. Audio Systems General Requirements:

1. Grounding: All grounding in racks is the responsibility of the AV contractor. All devices shall be appropriately grounded to the isolated grounding system busbar.
2. Un-Balanced Devices: Provide a balancing transformer for any unbalanced device, at both input and output.
3. Loudspeaker Rigging: All overhead loudspeaker rigging shall be reviewed and stamped by a licensed structural engineer working in the State of California. The contractor is responsible to secure the structural stamp, including all expenses associated therein.

B. Video Systems General Requirements:

1. Signal-to-noise ratio (peak to RMS) unweighted DC to 4.2MHz: 55dB minimum
2. Crosstalk: Unweighted DC to 4.2MHz: 45dB minimum
3. Frequency Response: Within plus or minus .5 dB to 4.2 MHz
4. Line and field tilt: 2% maximum
5. Differential Gain: 3% maximum
6. Differential Phase: 2 degree maximum
7. Video System timing: Sync coincidence within 50 nanoseconds
8. Color timing: Within 2 degrees at 3.58 MHz

C. Modulated (CATV) Video Systems General Requirements:

1. Cable Distribution System: The cable distribution system shall consist of coaxial cables, user interfaces, signal taps, splitters, RF amplifiers, signal equalizers, power supplies, and ancillary hardware as required to meet the system requirements specified below.
2. The signal level of each channel at each TV outlet shall be +5 dBmV, plus or minus 3 dBmV.
3. The system shall meet the following minimum parameters at each TV outlet:
 - a. Signal-To-Noise Ratio: 43 dB
 - b. Cross Modulation: -46 dB
 - c. Hum Modulation: -55 dB
 - d. Return Loss: 14 dB
 - e. Isolation (outlet-outlet): 24 dB
 - f. Aural Carrier Level: 13 dB to 17 dB below visual
 - g. Impedance: 75 ohm

2.3 MANUFACTURERS:

- A. AV equipment in this Section shall be provided by specialty manufacturers providing products meeting the drawings and the specifications herein.

2.4 COMPONENTS

- A. All equipment to be new and unused, except as detailed on the Drawings and set forth in this Specification.

2.5 MATERIALS:

- A. All components supplied under this Section shall be new. Used or factory reconditioned components will not be acceptable.
- B. Cabling
 1. Provide cabling as indicated in the drawings.
 2. The following cable colors shall be observed to comply with district standards:
 - a. Installed category data cabling: Orange
 - b. Category data patchcords: Orange
- C. Floor-standing 19" Equipment Rack (Theatre Amp Room):
 1. Provide Middle Atlantic WRK series. See drawings for exact size.
 2. Provided with solid rear locking door.
 - a. At Gymnasium: Provide with solid front locking door.
 3. Useable height shall be 44 rackspaces, useable depth shall be 30.75".
 4. 2,500 pound weight capacity.

5. All structural elements shall be finished in black powder coat.
 6. Rack shall be UL Listed.
 7. Provide the following options:
 8. Provide the following options:
 - a. Removable keylocked side panels, model # SPN-xxx. As required.
 - b. Top panel with 3-1/2" service plate model #MW-10FT. One per rack.
 - c. Lacer strip, heavily perforated, 77" long, model # LACE. Two per rack.
 - d. Rear rail kit, 11-gauge, 10-32 threaded, model # WRK-RRxxx. One per rack.
 - e. Copper Bus Bar, model #BB-xx. One per rack.
 - f. Magnetic Work Light, model #WL-60. One per rack.
 - g. Custom rack mounts for equipment without rack ears, model #RSH-series.
 9. Mount racks as necessary to meet Zone 4 / NFPA 5000 seismic requirements, based on manufacturer recommendations.
 10. Provide the following for thermal management:
 - a. 10" fan, model #FAN-10. One per rack.
 - b. 10" fan guard, model #GUARD-10. One per rack.
 - c. Vent Blockers, model VBK-W27-W32. As required.
 - d. Proportional Speed Thermostatic Fan Control, model #FC-4. One per rack group.
 - e. Vent panels at bottom of rack, model VT-series. As required.
 11. Provide the following for power management:
 - a. Modular power raceway, model #MPR-x. One per rack.
 - b. Remote-switched 20A Isolated Ground outlets, model RLM-20IG.
 - c. Sequencing Controller, model #USC-6R.
 - d. Non-switching front-mounted convenience outlets. Minimum one duplex outlet per rack. Provide Triplite DRS-1215.
 - e. 20A Remote power module, model #RLM-20-1C. As required.
 - f. 30A Remote power module, model #RLM-30-L530-1. As required.
 - g. Provide jumpers and accessories as required.
- D. Floor Standing Swing-Out 19" Equipment Rack (Theater Stage, Booths & Gym):
1. Provide Middle Atlantic SR-series. See drawings for exact sizes.
 2. 500 lb. weight capacity.
 3. All structural elements shall be finished in black powder coat.
 4. Rack shall be UL Listed.
 5. Provide the following options:
 - a. Solid Front Door, model #FD-xx.
 - b. Lacer strip, heavily perforated, 77" long, model # LACE. Two per rack.
 - c. Copper Bus Bar, model #BB-xx. One per rack.
 - d. Magnetic Work Light, model #WL-60. One per rack.
 - e. Custom rack mounts for equipment without rack ears, model #RSH-series.
 6. Provide the following for power management:

- a. Modular power raceway, model #MPR-XX. One per rack.
- b. Remote-switched 20A Isolated Ground outlets, model RLM-20IG. Quantity as required. Connect to master sequencing controller.
- c. Non-switching front-mounted convenience outlets. Minimum one duplex outlet per rack. Provide Tripplite DRS-1215.
- d. Provide jumpers and accessories as required.

E. Floor-Standing Pull-Out 19" Equipment Rack (Commons)

1. Provide Middle Atlantic MRK-AXS-Z4, in sizes as indicated in the drawings.
2. 500 lb. weight capacity, with seismic rating.
3. All structural elements shall be finished in black powder coat.
4. Rack shall be UL Listed.
5. Provide the following options:
 - a. Removable keylocked side panels
 - b. Top panel with 3-1/2" service plate model #MW-10FT. One per rack.
 - c. Lacer strip, heavily perforated, 77" long, model # LACE. Two per rack.
 - d. Rear rail kit, 11-gauge, 10-32 threaded, model # WRK-RRxx. One per rack.
 - e. Copper Bus Bar, model #BB-xx. One per rack.
 - f. Magnetic Work Light, model #WL-60. One per rack.
 - g. Custom rack mounts for equipment without rack ears, model #RSH-series.
6. Follow attachment methods as described in the drawings, which meet structural criteria provided by the project structural engineer.
7. Provide the following for thermal management:
 - a. 10" fan, model #FAN-10. One per rack.
 - b. 10" fan guard, model #GUARD-10. One per rack.
 - c. Vent Blockers, model VBK-W27-W32. As required.
 - d. Proportional Speed Thermostatic Fan Control, model #FC-4. One per rack group.
 - e. Vent panels at bottom of rack, model VT-series. As required.
8. Provide the following for power management:
 - a. Power raceways as required, model PDW-series.
9. Non-switching front-mounted convenience outlets. Minimum one duplex outlet per rack group. Provide Tripp Lite DRS1215.

F. Wall-Mounted Swing-Out 19" Equipment Rack (various locations)

1. Provide Middle Atlantic DWR Series.
2. Useable height shall be as required to fit equipment, useable depth shall be 26".
3. 250 lb. weight capacity.
4. All structural elements shall be finished in black powder coat.
5. Rack shall be UL Listed.
6. Follow attachment methods as described in the drawings, which meet structural criteria provided by the project structural engineer.
7. Provide the following options:

- a. Solid Front Door with keylock, model #FD-xx.
 - b. Custom rack mounts for equipment without rack ears, model #RSH-series.
 - c. Other items as shown in the equipment list.
8. Provide the following for power management:
 - a. Provide rack-mounted power distribution & sequencing device as indicated in the equipment list.
9. Provide the following for thermal management:
 - a. Dual rack-mount fan panel with thermostat, model UQFP-4. One per rack.
10. Vent panels at bottom of rack, model VT-series. One per rack
- G. Casework-Mounted Pull-out 19" Equipment Rack (various locations)
 1. Provide Middle Atlantic SRSRX-XX series.
 2. Useable height shall be determined by casework allowances, useable depth shall be 23".
 3. 200 lb. weight capacity.
 4. All structural elements shall be finished in black powder coat.
 5. Rack shall be UL Listed.
 6. Provide the following options:
 - a. Custom rack mounts for equipment without rack ears, model #RSH-series.
 7. Coordinate with casework provider to ensure proper ventilation.
 8. Provide a rack-mounted sequenced power distribution panel.
- H. Connectors:
 1. Microphone and Line Level Audio
 - a. XLR-M, 3-pin:
 - 1) For panel-mount, Provide Neutrik NC3MD-L-1, 3-pole male XLR connector in black.
 - 2) For cable-end, provide Neutrik NC3MXX, 3-pole male connector.
 - b. XLR-F, 3-pin, Standard
 - 1) For panel-mount, Provide Neutrik NC3FD-L-1, 3-pole female XLR connector in black.
 - 2) For cable-end, provide Neutrik NC3FXX, 3-pole female connector.
 - c. XLR-F, 3-pin, Automixing (BLUE)
 - 1) For panel-mount, Provide Whirlwind WC3F, 3-pole female XLR connector in blue color shell.
 - 2) No colored trim rings allowed, such as Neutrik.

- d. 1/4" Tip/Ring/Sleeve
 - 1) For panel-mount, Provide Neutrik NJ3FP6C, locking tip/ring/sleeve connector.
 - 2) For cable-end, provide Neutrik NP3X, tip/ring/sleeve connector.
- e. Phono
 - 1) For panel-mount, Provide Neutrik NF-2D series, with appropriate color isolation washer.
 - 2) For cable-end, provide Neutrik NF2C-B-2 "Profi" connector.
- f. MASS Multi-pin
 - 1) The MASS series of cables (with the exception of the 12-pair model) is a sexless multi-pin cabling system. Care shall be taken to configure the connectors appropriately.
 - 2) Configure MASS connectors using the manufacturer-recommended wiring scheme.
 - 3) Chassis Mount
 - a) 12-pair cable, provide W1CF, 39-pin chassis-mount female
 - b) 16-pair cable, provide WSCR MicroMASS 48 pin chassis-mount
 - c) 28-pair cable, provide W6CRP MicroMASS 84 pin chassis-mount
 - d) 40-pair cable, provide W3CRP MASS 122 pin chassis-mount
 - e) 58-pair cable, provide W4CRP MASS 176 pin chassis-mount
 - 4) Cable End
 - a) 12-pair cable, provide W1IF or W1IM, 39-pin inline connector (as required)
 - b) 16-pair cable, provide WSIRP MicroMASS 48 pin inline connector
 - c) 28-pair cable, provide W6IRP MicroMASS 84 pin inline connector
 - d) 40-pair cable, provide W3IRP MASS 122 pin inline connector
 - e) 58-pair cable, provide W4IRP MASS 176 pin inline connector
 - 5) Solder Cup style connectors are not acceptable.
- 2. Production Intercom:
 - a. XLR-M, 3-pin, Intercom (RED)
 - 1) For panel-mount, Provide Whirlwind WC3M, 3-pole male XLR connector in red color shell.
 - 2) No colored trim rings allowed, such as Neutrik.
- 3. Integrated Control Systems:
 - a. For panel-mount in configurations using legacy data and power bus (AxLink or Cresnet), provide Neutrik NC4FD-L-1, 4-pole female XLR connector.

- b. For panel-mount in configurations using networked control bus, refer to RJ-45 data information below.
 - c. Cable-end configurations are project dependent. See drawings.
- 4. Loudspeaker:
 - a. For panel-mount in 2 or 4-conductor applications, use Neutrik Speakon NL4MP 4-pole connector.
 - b. For panel-mount in 8-conductor applications, use Neutrik Speakon NL8MPR 8-pole connector.
 - c. For cable-end in 2 or 4-conductor applications, use Neutrik Speakon NL4FC 4-pole connector.
 - d. For cable-end in 8-conductor applications, use Neutrik Speakon NL8FC 8-pole connector.
- 5. Video:
 - a. Production Video:
 - 1) For panel-mount, Provide Neutrik NBB75DFIB, Recessed bulkhead jack, feed through, isolated connector.
 - 2) For cable-end, provide Neutrik NBNC75P-series, push-pull style connector. Use appropriate connector for cable specified.
 - b. "F" Connector:
 - 1) For panel-mount, provide Cencom GF81 inline barrel connector with 1 GHz minimum performance.
 - 2) For cable-end, provide Cencom Superlock compression connector with 1 GHz minimum performance.
- 6. Data:
 - a. RJ-45
 - 1) For panel-mount, provide Neutrik Ethercon NE8FDP-B feed-thru connector in black.
 - 2) For cable end, provide Neutrik Ethercon NE8MC-series connectors.
 - b. Fiber
 - 1) For panel-mount, provide Neutrik Opticalcon NO2-4FD feed-thru panel mount connectors.
 - 2) For cable end, provide Neutrik Opticalcon cables in quantities shown in 274116-A equipment list.
- 7. Patchbays:
 - a. Microphone and Line Level Audio:

- b. Provide Bittree 489 programmable series with 3-pin molex style termination with the following options:
 - 1) Longframe 1/2"-style connectors
 - 2) 2x26 jacks with 12" deep chassis
 - 3) 2 designation strips in over/under configuration
 - 4) Mono spacing, 2 RU
 - 5) Isolated Grounding
 - 6) Normals per Drawings
 - 7) Black in color
 - 8) Paper designation strips. Provide .doc file to Owner for future use.
 - 9) Provide Middle Atlantic "CLAW" patchcord holder, one per rack.
 - c. Patchbay layout shall be in standard "output at top, inputs at bottom" scheme with clear method for showing normals. Contractor shall be responsible for exact patchbay layout.
 - d. Labeling shall be as follows:
 - 1) All labeling shall exactly match circuit in field.
 - 2) Labeling shall be sequential per circuit type, beginning at 1.
 - e. Patchbays by AVP, Inc are also acceptable.
8. Loudspeaker:
- a. Provide AVP, Inc. WK-U212E3-NL4MP series with solder termination and the following options:
 - 1) 2x12 jacks with 12" deep chassis
 - 2) 2 designation strips in over/under configuration
 - 3) 2 RU
 - 4) Black in color
 - 5) Paper designation strips. Provide .doc file to Owner for future use.
 - b. Provide 2 output jacks from each amplifier channel. Configure as follows:
 - 1) Amplifier "A", Channel One Jacks:
 - a) Pins 1+/1- : Amp Channel One
 - b) Pins 2+/2-: Amp Channel Two
 - 2) Amplifier "A", Channel Two Jacks:
 - a) Pins 1+/1- : Amp Channel Two
 - b) Pins 2+/2-: No Connection
 - c) See Drawings for additional information.
 - d) Provide Middle Atlantic "CLAW" patchcord holder, one per rack.
9. Composite/HD-SDI Production Video:

- a. Provide Bittree Video WECO Composite series Hi-Definition patchbay.
- b. Provide the following configuration:
 - 1) WECO-style connectors
 - 2) 2x26 jacks with 12" deep chassis
 - 3) 2 designation strips in over/under configuration
 - 4) 2 RU
 - 5) Normals per Drawings
 - 6) Black in color
 - 7) Paper designation strips. Provide .doc file to Owner for future use.
 - 8) Provide Middle Atlantic "CLAW" patchcord holder, one per rack.
- c. Patchbays by AVP, Inc. in are also acceptable.

10. Data:

- a. RJ-45
 - 1) Leviton Gigamax 6-series patchbays, with STP support as needed.
- b. Fiber
 - 1) Corning Cable Systems LanScape CCH-series patchbays

2.6 PANELS:

- A. General: The control receptacle panels shall consist of the appropriate connectors required for the system.
- B. Physical:
 - 1. Faceplates shall be 0.080" aluminum, edges eased, finished in fine texture, scratchresistant powder coat, with fasteners countersunk.
 - a. Panels specified as flush mounted shall overlap back box by 1/2". Surface mounted panels shall match back box size with no gaps or overlap.
 - b. Coordinate back box type, size and mounting with Division 26 - Electrical.
 - 2. Color shall match the finished wall color of the wall onto which it will be mounted, unless otherwise noted. Submit color table for review.
 - 3. Panels noted as custom color shall be factory powder coated a color selected by the Architect. Legends shall be laser etched.
 - 4. Laser etched labels 1/4" high characters minimum, unless otherwise noted.
 - a. Labeling shall be as indicated on the Drawings.
 - b. Use Arial font.
 - 5. Wall mounted panels shall mount into an industry standard back box, depending on size and quantity of connectors.
 - 6. Rack mounted panels shall mount within industry standard equipment racks.

7. Panels mounted in floor boxes shall include a translucent flexible vinyl dirt guard as indicated on Drawings.
8. Provide complete hardware for mounting on gridiron hangers where indicated on the Drawings.
9. Provide aluminum cable tie-off bars in matching color on all panels 8" wide and larger, as indicated on the Drawings.
 - a. Keystone Electronics Corporation "Aluminum Oval Instrumentation Handles", part number 546, 5" wide x 2" deep handle. www.keyelco.com; 800-221- 5510

C. Floor Pockets:

1. Provide flush, floor mounted pockets with cover and cable slot. Lid finish and lid type to be determined during submittal period from manufacturer's standard line.
2. Provide interior, flexible translucent PVC dirt guard to cover receptacles. Labels shall remain visible.
3. Provide floor pocket backboxes and pour pans (if conditions warrant) to Division 26 - Electrical for installation

2.7 SYSTEM DESCRIPTION;

A. Flat Panel Mounting

1. Several types of flat panel mounting are described in the equipment list. Provide and install complete mounting system to match the condition noted in the drawings.

B. Commons

1. Audio
 - a. Provide an audio matrix with automixer function and wireless microphone system as indicated in the equipment list.
 - b. The audio matrix unit shall also include an audio networking port, to allow audio related to the production facilities (main & blackbox theatre) to be routed to the commons area. Audio may include program audio from either space, recall chimes, paging from the house manager panels, or background music.
 - c. The voice reinforcement loudspeaker system includes ceiling-mounted and column-type loudspeakers.
 - d. Configure column speaker with proper steering to get audio into the listener area.
 - e. Provide equipment rack and power conditioning and sequencing devices per equipment list.
 - f. Provide an ADA-compliant Assistive Listening System, complete with accessories as shown in the equipment list.
 - g. Provide a single-channel production intercom power supply for simple event use.
2. Video Wall
 - a. Provide a 5x2 video wall system, complete with digital signage playback system.

- b. The video wall shall be mounted such that any individual display can be pulled out for access.
 - c. Provide on-site commissioning services from the video wall manufacturer.
 - d. The digital signage players shall be configured to playback one large image over the entire video wall.
- 3. Digital Signage
 - a. Install owner-provided flat panels at locations shown in the drawings.
 - b. Provide network-based digital signage players at each displays, and configure to work over building-wide data system.
 - c. Provide and install the digital signage control software on one computer, or on a virtual server, as directed by the owner.
 - d. Provide two 4-hour training sessions on the digital signage system, in addition to other training required in this section.
- 4. Control
 - a. Provide a touchscreen-based control system, with one 5" touchpanel in a locking enclosure.
 - b. Provide all programming for a complete system. See programming section below.

C. Choir / Band Room

- 1. The standard classroom AV system is comprised of a main switcher and signal transport unit located at the equipment rack, along with a control panel located near the front of the room. The control panel shall be connected to the building-wide data system for future connection to a building-wide management system. Coordinate with electrical for connection. The control system shall connect to all devices in the room, and allow for typical control items, such as power, volume, source select, etc.
- 2. Install owner-provided 1080p flat-panel display at location indicated in the drawings and equipment list. Provide and install wall mount.
- 3. Loudspeakers are wall-mount type. Mount as required to clear lighting and other obstructions, while providing even audio coverage in the student seating area.
- 4. The system will provide local inputs for connecting HDMI laptop computers. Laptop computers & portable video players will be provided by owner.
- 5. Provide an RS-232 controlled blu-ray player with rack mount.
- 6. Provide a wireless microphone system with bodypack/lavalier transmitter, rechargeable battery and battery charger.
- 7. Provide an audio mixer with CD/Flash recorder and (2) hanging ceiling microphones for making simple recordings.
- 8. Provide a pull-out rack for all equipment. Coordinate with casework to confirm proper fit. Provide (2) thermostat-controlled fans to assist with heat removal. See drawings for additional information.
- 9. Provide and install all necessary equipment and accessories for a complete and working system.
- 10. See architectural & electrical sheets for proper placement of AV devices

D. Recording Studio

1. The contractor shall deliver a fully-functional "turn-key" recording studio.
2. The recording studio shall support the digital recording of audio from the studio or the adjacent music classrooms. Infrastructure shall be provided to bring analog and digital signals from other spaces.
3. A multi-track capable digital recording system shall be provided, complete with digital recording console and computer-based recording software and necessary input/output devices using the Thunderbolt interface.
4. The computer shall be Apple Macintosh desktop style, and shall be configured based on the recording software manufacturer's typical hardware requirements. Additional requirements include:
 - a. One Six-core processor (3.5GHz Intel Xeon E5 or better)
 - b. Dual GPU (AMD FirePro D500 or better)
 - c. 32.0 GB internal RAM
 - d. 1.0 TB PCIe based flash storage
 - e. Rack-mounted in enclosure with thunderbolt-based PCI expansion chassis, blu-ray drive, and removable hard drive storage.
5. The contractor shall be responsible to ensure that necessary parameters of the recording software are accessible via the digital console.
6. A pair of 24" digital video monitors on articulating arms shall be used for local video monitoring of computer & console functions.
7. A pair of 65" monitors shall be positioned above the vocal booth window so that all class members may see. The 65" monitors shall be fed with a discreet digital video signal from the computer, via Thunderbolt to HDMI converter and HDCP compliant HDMI link. The 65" monitors shall be configured to be part of the CPU's desktop.
8. A digital musician-monitoring system shall be provided, and allow for each musician to have control over their own multi-track mix using local mixing devices and headphones.
9. A far-field self-powered left/right audio monitoring system with subwoofer shall be provided.
10. A longframe 1/2" audio patchbay, with programmable normals shall be provided for audio signal as shown on the drawings.
11. A remote-control breaker panel shall be provided by electrical. A remote control panel shall be provided by the AV contractor to start up/shut down the entire system.
12. A UPS (Uninterruptable Power Supply) shall be provided for all computer-based equipment. The UPS shall be fanless, and rack-mounted.
13. Recording lights shall be provided, at locations as shown on the drawings. A relay and switch shall be provided to activate the lights.
14. Custom studio furniture shall be provided. Base model furniture model S3 1-2 shall include:
 - a. (qty 1) S3 desk w/ rear closure panels
 - b. (qty 2) 3RU top racks
 - c. (qty 1) 12RU slant rack
 - d. (qty 1) 12RU isobox
 - e. (qty 1) keyboard pull-out tray
 - f. (qty 3) 14RU slant racks w/ single countertop
 - g. The source of the furniture shall be:

- 1) Sound Construction & Supply; 1328 Vashti Street, Nashville, TN 37207;
Phone: 615.226.5150; Fax: 615.226.5149; Contact: Todd Beeten

E. Lobby/Corridor - Digital Signage

- a. Install owner-provided flat panels at locations shown in the drawings.
- b. Provide network-based digital signage player at each display, and configure to work over building-wide data system.
- c. Provide and install the digital signage control software on one computer, or on a virtual server, as directed by the owner.
- d. Provide two 4-hours training sessions on the digital signage system, in addition to other training required in this section

2.8 A/V SYSTEM HEAD-END

- A. AV Network Switch: AMX NMX-ENET-500-24-POE. Provide (2).
- B. AMX NMX-SFP-MM. Provide (4)
- C. DANTE BRIDGE: BSS Soundweb London BLU-DAN. Provide (2).

2.9 A/V SYSTEM FOR DANCE ROOM

- A. Audio DSP: BSS Soundweb London BLU-100
 1. Provide with cards as necessary to meet functional requirements.
 2. Connect to Intercom system for playback of Intercom paging.
- B. Intercom System Ingest and Audio Override: Provide connectivity to building intercom system room speaker so that announcements from the intercom system will automatically mute any active program or mic audio in the AV system and play such intercom announcements through the AV system speakers. Playback of intercom announcements through the AV system are supportive of the classroom intercom speaker and is intended to enhance, not replace the intercom system speaker. RDL ST-ACR1 with associated power supply, matching transformer, impedance matching and level matching as required to make an operational system.
- C. Equipment Rack: Middle Atlantic PTRK-XX-MDK. Provide sufficient panel space to accommodate all equipment. Provide lockable drawer to store loose items. Provide with solid locking front door. Provide with blanks and vents.
- D. Equipment Rack Power Distribution: Middle Atlantic Series Protection or equal as required..
- E. Wire and Cable (plenum as required)
 1. Speakers #12x2 Overall Jacket – Belden 5000UE
 2. Multi-Pair Audio: Belden 18XXR (pair count as required)
 3. RGBHV: Belden 7712A

4. HDMI: Extron – length as required. Provide UTP transceivers for all HDMI runs over 50 feet.
5. Video: Belden #1694A

2.10 A/V SYSTEM FOR BAND, CHOIR, AND MUSIC ROOM

- A. Cabled Microphones: Shure SM58. Provide 4. M. Provide 4 15-foot cables.
- B. Ceiling Microphones: Shure CVO Overhead Condenser Microphones. Provide complete with Neutrik NC3FDL-1 connectors on black anodized aluminum plate for microphone locations in ceiling as shown in drawings. Aim microphones for maximum audio pick-up.
- C. Audio DSP: BSS Soundweb London BLU-100
 1. Provide with cards as necessary to meet functional requirements.
 2. Connect to Intercom system for playback of Intercom paging.
- D. Intercom System Ingest and Audio Override: Provide connectivity to building intercom system room speaker so that announcements from the intercom system will automatically mute any active program or mic audio in the AV system and play such intercom announcements through the AV system speakers. Playback of intercom announcements through the AV system are supportive of the classroom intercom speaker and is intended to enhance, not replace the intercom system speaker. RDL ST-ACR1 with associated power supply, matching transformer, impedance matching and level matching as required to make an operational system.
- E. Equipment Rack: Middle Atlantic PTRK-XX-MDK. Provide sufficient panel space to accommodate all equipment. Provide lockable drawer to store loose items. Provide with solid locking front door. Provide with blanks and vents.
- F. Equipment Rack Power Distribution: Middle Atlantic Series Protection or equal as required..
- G. Wire and Cable (plenum as required)
 1. Speakers #12x2 Overall Jacket – Belden 5000UE
 2. Microphone / Line: #22x2 Shielded Overall Jacket – Belden 9451
 3. Multi-Pair Audio: Belden 18XXR (pair count as required)
 4. RGBHV: Belden 7712A
 5. HDMI: Extron – length as required. Provide UTP transceivers for all HDMI runs over 50 feet.
 6. Video: Belden #1694A

2.11 AV SYSTEM FOR COMMONS STAGE PERFORMANCE SYSTEM

- A. Audio DSP: BSS Soundweb London BLU-100
- B. Signal Splitters: Provide isolation / split transformers as shown on the drawings: ProCo MS82P, MBT-2 and MMT-1 as required to meet functional requirements. Provide phantom power pass-through on microphone channels.

- C. Intercom System Ingest and Audio Override: Provide connectivity to building intercom system room speaker so that announcements from the intercom system will automatically mute any active program or mic audio in the AV system and play such intercom announcements through the AV system speakers. Playback of intercom announcements through the AV system are supportive of the classroom intercom speaker and is intended to enhance, not replace the intercom system speaker. RDL ST-ACR1 with associated power supply, matching transformer, impedance matching and level matching as required to make an operational system.
- D. Microphones:
1. Cabled Microphones: Shure SM58. Provide six (6) with 20' cables, 4 50-foot extension cables, and 1 100-foot extension cable.
 2. Wireless Handheld Microphone: Shure ULX-D2/B58 Handheld system. Provide two (2) systems, complete with rack mount kit, cables, power supplies, etc.
 - a. Connect to antenna distribution system. Show antenna location in shop drawings for approval prior to installation.
 - b. Provide frequency selections that are compatible with existing frequencies and expandable to a total of 12 systems. Provide frequency channel information for installed systems to Owner, with operations and maintenance manuals, to facilitate future purchases of additional systems.
 3. Wireless Headset Microphone: Shure ULX-D1 Headworn system.
 - a. Provide two (2) systems, complete with rack mount kit, cables, power supplies, etc.
 - b. Provide two (2) Countryman ISOMAX Headsets. Beige color.
 - c. Connect to antenna distribution system. Show antenna location in shop drawings for approval prior to installation. Coordinate and provide remote antenna mounting for proper reception from transmitters in the theatre, to receivers in rack.
 4. Ceiling Microphones: Shure CVO Overhead Condenser Microphones. Provide complete with Neutrik NC3FDL-1 connectors on black anodized aluminum plate for microphone locations in ceiling as shown in drawings. Aim microphones for maximum pick-up of stage audio.
- E. Assisted Listening System:
1. Williams Sound PPA 457 PRO System with transmitter and 4 receivers (provide 1 system).
 2. Provide complete system with rack mount, power supply, rechargeable receiver batteries.
 3. Show antenna location in shop drawings for approval prior to installation.
- F. Equipment Racks: Middle Atlantic ERK-XX. Provide sufficient panel space to accommodate all equipment. Provide lockable drawer to store loose items. Provide with solid locking front door. Provide with blanks and vents.
- G. Equipment Rack Power Distribution: Middle Atlantic Series Protection or equal as required.
1. Wire and Cable (plenum as required)
 2. Speakers #12x2 Overall Jacket - Belden 5000UE
 3. Microphone / Line: #22x2 Shielded Overall Jacket - Belden 9451

4. Multi-Pair Audio: Belden 18XXR (pair count as required)
5. RGBHV: Belden 7712A
6. HDMI: Extron - length as required. Provide UTP transceivers for all HDMI runs over 50 feet.
7. Video: Belden #1694A

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Coordinate work with other trades to avoid causing delays in construction schedule.
- B. Mount equipment and enclosures plumb and square. Permanently installed equipment to be firmly and safely held in place. Design equipment supports so support loads imposed with a safety factor of at least 3 (5 to 1 for loudspeaker mountings).
- C. The process of acceptance testing the System may necessitate moving and adjusting certain component parts, such as loudspeakers. Provide for +/- 10 degrees of adjustability from initial aiming angle and perform such adjustments without claim for additional payment.
- D. Cover edges of cable pass-through holes in chassis, racks, boxes, etc. with rubber grommets or Brady GRNY nylon grommets.
- E. Devices mounting in acoustical tile ceilings to be properly supported with tile bridges or other similar structural bracing.
- F. AC Power and Grounding:
 1. Coordinate final connection of power and ground wiring to racks. Hard wire power wiring directly to power contactors or internal AC receptacles to ensure uninterrupted operation, as required.
 2. Install 3-conductor, isolated ground, 120 VAC outlets in each rack. Provide a minimum of 2 spare outlets in each rack. Label each outlet as to which AC circuit is feeding it and provide the same information in the circuit breaker panel.
 3. Install a 1 inch by 1/4 inch copper ground buss bar top to bottom in each rack, insulated from the rack. Ground equipment chassis not having a 3-wire power cord to these busses using 10/32 nuts, bolts, and lockwashers with No. 12 wire. Connect green ground wire from each AC outlet in rack to this buss bar.
- G. Equipment Racks:
 1. Mount equipment in racks and consoles and jully wire and test before delivery to job site. If field conditions prevent prior assembly of racks, notify Owner in writing that racks will be fabricated on site and the reasons for the change. Racks located on concrete floors in equipment rooms or non-finished spaces to mount on a 4 inch wood or concrete riser.
 2. Provide ventilation adequate to keep temperature within the rack below 100 degrees Fahrenheit. Provide whisper type ventilation fan in each rack if temperature in rack rises above 100 degrees with power on for five continuous hours.

3. In general, looking at the rack from the rear, locate AC power, digital control, DC control, and speaker wiring on the left; microphone, line level audio, and video wiring on the right. Panels or equipment mounted on the rear rack rails shall not block access to any front mounted components.

H. System Wiring:

1. Take precautions to prevent and guard against electromagnetic and electrostatic hum. For line level audio signals, float cable shields at the output of source device. Shields not connected to be folded back over cable jacket and covered with heat-shrink tubing. Do not cut off unused shields.
2. Exercise care in wiring: damaged cables and equipment will not be accepted. Isolate cables of different signals or different levels and separate, organize, and route to restrict channel crosstalk or feedback oscillation in any amplifier section. Lace wiring and separate into groups for microphone and line level circuits, loudspeaker circuits, and power circuits.
3. Make connections with rosin-core solder or with mechanical connectors approved by the Owner. Where spade lugs are used, crimp properly with ratchet type tool. Spade lugs mounted on 22 gage or smaller cable to be soldered after crimping. Wiring entering equipment racks and at CIP should connect via terminal blocks (Cinch 140-142 Series) or punch blocks designed for stranded wire. Terminal blocks shall be fully exposed, labeled, and mounted on 3/4 inch plywood board painted flat black. If quantity of terminals is too numerous to fit in rack, terminal blocks may be located on wall mounted plywood terminal board adjacent to rack. Mounting boards to be 3/4 inch AIC grade or hardwood plywood painted flat black. Terminal board wiring to meet the same requirements as internal rack wiring described below.
4. Route unbroken microphone, audio line, and control wiring from receptacle plate/chassis to patch panel/rack. Remove spliced cables and replace without additional charge to the Owner. Connect cable to active components through screw terminal connections and spade lugs whenever available.
5. Make connections to speaker transformers with properly sized closed end connectors crimped with factory approved ratchet type tool. Wire nut or "Scotchlock" connectors are not acceptable. Do not wrap audio cable splices or connections with adhesive-backed tape.
6. Execute wiring in strict adherence to "standard broadcast practices", as excerpted from "Recommended Wiring Practices", Broadcast Audio Equipment for AM, FM, Television (5th Edition), Radio Corporation of America (RCA), Camden, NJ 1962 and Appendix II, "Recommended Wiring Practices", Sound System Engineering, (2nd Edition), D. Davis, and performed in accordance with standard professional practice.
7. Run vertical wiring inside rack in properly sized plastic raceway with snap-on covers (Panduit Type E series). Mount raceways on full length 3/4 inch plywood backboards attached to rack sides. Horizontal wiring in rack to be neatly tied in manageable bundles with cable lengths cut to minimize excess cable slack but still allow for service and testing. Provide horizontal support bars if cable bundles sag. Neatly bundle excess AC power cable from rack mounted equipment with plastic cable ties. Rack wiring to be bundled with plastic cable ties or lacing twine. Electrical tape and adhesive backed cable tie anchors are not acceptable.
8. Connect loudspeakers electrically in phase, using the same wire color code for speaker wiring throughout the project.

9. Wiring and connections shall be completely visible and labeled in rack. Termination resistors shall be 1/2 watt 5 percent tolerance, fully visible, and not concealed within equipment or connectors.

I. Equipment and Cable Labeling:

1. Provide laser engraved labels on the front and rear of active equipment mounted in racks. Mount labels in a neat, plumb and permanent manner. Embossed labels or P-Touch type labels are not acceptable. Equipment labels to have at least three lines of engraving with the first line listing the general name of the device, i.e. POWER AMPLIFIER or EQUALIZER, the second line to include the schematic reference of the device i.e. PO-1A or MIXER-3, and the bottom line to indicate what other devices or areas this equipment controls i.e. FEEDS HF-3&4 or FEEDS XOVER-3.
2. Provide an engraved label over each user-operated control that describes the function or purpose of the control. Label size to be adjusted to fit available space. Engraved labels to have 1/8 inch high characters typical. Labels to be black with white characters except where indicated. Embossed or P-Touch type labels are not acceptable.
3. Cables and wiring to be logically, legibly, and permanently labeled for easy identification. Labels on cables to be adhesive strip type covered with clear heat-shrink tubing. Factory stamped heat shrink tubing may be used in lieu of the adhesive strip style label. Hand written labels not acceptable.
4. Wiring designations to be an alpha-numeric code that is unique for each cable. Locate the cable designation at the start and end of each cable run, and within 3 inches of the point of termination or connection. For cable runs that have intermediate splice points at riser junction boxes, the cable shall have the same designation throughout with an additional suffix to indicate each segment of the run. Actual cable designation assignments to be determined by Contractor.
5. Add cable designation codes to system schematic drawings included with Project Record Drawings.
6. Label each terminal strip with a unique identification code in addition to a numerical label (cinch MS series) for each terminal. Show terminal strip codes on system schematic drawings included with Project Record Drawings.
7. Provide adhesive labels on the rear of equipment where cables attach to indicate the designation of the cable connected at that point.

J. Outdoor Mounting of Equipment (if applicable):

1. Objects mounted outdoors shall be properly treated for exposure to moisture and temperature extremes.
2. Mounting hardware to be non-corrosive type.
3. Structural supports for speakers or other equipment to have inherent corrosion resistance or be covered with a corrosion inhibiting layer.
4. Speaker component mounted in exterior environments to be rigidly connected to the structure to prevent movement caused by wind gusts.
5. Speaker enclosures to include grille capable of breaking up direct water sprays or rain.
6. Seal all electrical connections on speaker enclosure with waterproof sealant.
7. Treat paper cones of speakers with silicone based moisture repellant.
8. Provide screened cover over all openings in horn type speakers to keep out birds, insects, and small animals. Screened covering to be stretched taught with no visible wrinkles.

3.2 CABLE INSTALLATION:

- A. Mark cables, regardless of length, with permanent, non-handwritten number or letter cable markers within 6-inches of both ends. There shall be no unmarked cables in the system. Marking codes used on cables shall correspond to codes used on Drawings and schedules.
- B. As indicated on the Drawings, group cables according to signal type. Up to 6 separate conduit systems may be in place, divided as follows:
 - 1. Microphone Level Audio
 - 2. Line Level Audio
 - 3. Video and Communication Level
 - 4. Loudspeaker Level
 - 5. Empty/Future expansion
 - 6. Fiber Optic Level
- C. As much as possible, maintain separation of signal types when outside of conduit.
- D. No cable shall be installed with a bend radius less than recommended by the manufacturer.
- E. Cables types shall be as indicated on the Drawings. In plenum spaces, provide the plenum version of the specified cable type.
- F. No cable splicing is allowed, except for systems that are daisy-chained.
- G. Upon completion of the installation, the Contractor shall notify the Architect that the system is available for formal checkout. Notification shall be provided in writing. Checkouts shall be scheduled in accordance with the Architect's schedule.
- H. Audio System Tuning:
 - 1. Following complete system installation, each device shall be set for correct gain-staging.
 - a. This is best accomplished with an oscilloscope and a 400Hz tone generator, but other methods may be used.
 - b. If the system has been set correctly, the console's VU meters will be at zero when the system is accomplishing the specified dB-SPL level. Every device in the audio signal path should clip at the same level, maximizing headroom and keeping the noise floor to a minimum.
 - 2. System shall be tuned prior to final checkout by contractor, using a computer-based audio analysis program, such as SMAART, TEF, or SIMM. A factory-certified individual shall carry out the tuning.
- I. Cable Television System Tuning:
 - 1. Following complete installation, each device in the CATV system shall be tuned to exact an output of
+5 dBmV, +/- 3 dBmV at the television output.

2. Audio input at the modulator shall be set in accordance with the gain staging requirements covered in the audio sections.
 3. Video input at the modulator shall be set per manufacturer's guidelines.
- J. Provide to the Architect and or his Consultant the following upon arrival:
1. Measurements of impedance of each loudspeaker prior to connecting it to an amplifier.
 2. Measurements confirming the polarity of each loudspeaker, from output of console through entire system.
 3. Measurements showing all Ethernet wiring complies with Category 5e or Category 6 requirements for full bandwidth operation.
 4. Verification that every line has been sweep tested and conforms to standard requirements per signal level.
 5. Measurements showing CATV output voltage at each TV outlet.
 6. Demonstration of input and output of signal throughout the entire audio system.
- K. Make available for review by the Architect and or his Consultant:
1. All components for physical inspection and inventory.
 2. A computer to access any DSP units.
 3. All installed devices in full operation, with no temporary equipment in place.
 4. All portable devices, fully complete, and available to test at all plug-in locations.
 5. Test equipment, including:
 - a. High quality media for every presentation source
 - b. Video and RGBHV test generators
 - c. Portable TV with CATV receiver input
 - d. AC voltmeter
 - e. Sound level meter
 - f. Portable amplified loudspeaker
 - g. Waveform monitor (oscilloscope)
 - h. Audio analysis equipment (provides real time display, pink noise source, test oscillator, level and THD+N measurements)
 - i. Cables, sets, adapters, and connectors for inserting the test equipment into and out of the system's user interfaces and connector plates.
- L. The Contractor shall be liable for any return visits by the Architect and/or his consultant as a result of incomplete or incorrect installation, or erroneous representation that the Systems are complete and ready for the Architect to carry out its work.
1. The Contractor shall arrange for access as necessary for inspection of equipment by the Architect and or his consultant
- M. Upon completion of the commissioning, Contractor shall demonstrate operation and maintenance of the system to the Owner. Coordinate with the Owner's schedules two weeks in advance minimum

3.3 CONTRACTOR'S TESTS, SETUPS, AND ADJUSTMENTS

- A. Verify the following before beginning actual tests and adjustments on the system:
1. Electronic devices are properly grounded.
 2. Powered devices have AC power from the proper circuit and hot, neutral, and ground conductors are connected correctly.
 3. Insulation and shrink tubing are present where required.
 4. Dust, debris, solder, splatter, etc. is removed.
 5. Cable is dressed, routed, and labeled; connections are consistent with regard to polarity.
- B. Grounding System Tests:
1. Measure and record the DC resistance between the technical ground in any equipment rack or console and the main building ground. Resistance should be at least 0.15 ohms or less.
 2. Temporarily lift the technical ground from the main electrical ground, measure and record the DC resistance between them. Resistance should be at least 1000 ohms.

3.4 GROUNDING

- A. Prior to energizing or testing the system, ensure the following:
1. All product is installed in a proper and safe manner per the manufacturer's instructions.
 2. Insulation and shrink tubing are present where required.
 3. Dust, debris, solder, splatter, etc. is removed.
 4. Cable is dressed, routed, and labeled; connections are consistent with regard to polarity.
 5. All labeling has been provided.
 6. Temporary facilities and utilizes have been properly disconnected, removed, and disposed of off-site.
 7. All products are neat, clean, and unmarred, and parts are securely attached.
 8. All broken work, including glass, raised flooring and supports, ceiling tile and supports, walls, doors, etc. have been replaced or properly repaired, and debris cleaned up and discarded.
 9. Electronic devices are properly grounded.
- B. Prior to energizing the system, perform the following tests in compliance with applicable EIA standards. Provide a draft of a proposed test report form for review as part of the submittal process. Record the results of each test in the Project Record Manual and have a copy available for the Owner during inspection.
1. Test each AC power receptacle with a circuit checker to proper hot, neutral, and ground connections.
 2. Measure and record the DC resistance between the technical ground in any equipment rack or console and the main building ground. Resistance should be 0.15 ohms or less.
 3. Temporarily lift the technical ground from the main electrical ground, measure and record the DC resistance between them. Resistance should be 1000 ohms or greater.
 4. Measure the impedance of each speaker line leaving the equipment racks. For full range devices, use a frequency of 1000 Hz, for band limited devices use a frequency appropriate for the operating range of the transducer. When documenting the results of these tests,

include the calculated impedances based on number of units on a line and the size and distance of the run. Correct any field readings that differ more than 20 percent from the calculated impedances.

C. Speaker Circuit Verification Test:

1. Provide a low level, distinctive test tone to each amplifier input.
2. Turn on one channel of Amplifier #1 and verify that the correct speaker or group of speakers is operating. Correct any wiring or other problems found.
3. In a similar manner, check each channel of all remaining amplifiers and their respective speaker circuits.
4. Include the results of the tests in the Project Record Manual.

D. Volt Speaker Test:

1. Play music, pink noise, or other distinctive audio signal through each group of 70 volt speakers.
2. Walk the area covered by the speakers.
3. Verify that each speaker is operating and that there are no significant changes in volume level from one speaker to the next.
4. Verify that the extent of coverage is consistent with the areas indicated on the drawings.

E. Speaker Polarity Verification Test:

1. Use an electronic polarity checker, TEF machine, JBL SMAART PRO, SIM II, or other similar device to test each reinforcement speaker. All speakers should have the same relative polarity.
2. Follow manufacturer's recommendations in conducting the tests.
3. In a similar manner, check all distributed speakers to ensure they have the same polarity.
4. Include the results of the tests in the Project Record Manual.

F. System Gain Adjustment:

1. Adjust each active device to have unity gain from the console output to the input of the crossover.
2. With all amplifiers turned off, connect a sine wave or pink noise generator to the input of the console. Using an RMS AC voltmeter with a dB scale, adjust the console to an output between -10 and 0 dBu. Once the level has been established, it should remain unchanged throughout the test. All equalizers should be set flat for this test.
3. Follow the signal flow from the console to each subsequent component. Measure the input level and output level of each device at the point of connection to the device. The input level reading should differ no more than 0.25 dB from the level recorded for the preceding device. Diagnose and correct the wiring or equipment when any readings exceed this range.
4. Adjust the output level of each component to match the reference level coming from the console.
5. Output level should differ no more than 0.5 dB from the console output level.
6. Record the output levels of each device on the Project Record Drawings.

G. Amplifier Level Adjustment:

1. Adjust the gain of each amplifier to provide a consistent and appropriate volume level throughout the facility.
2. Begin by connecting a pink noise source to one input of the mixing console. Adjust the console output to -10 dB on the VU meter.
3. Using main reinforcement speakers, adjust the appropriate amplifiers to achieve 85 dBA in the area covered by the speakers. Use a calibrated sound level meter to take the measurement. Amplifiers should be set to provide an average of 85 dBA + 1.5 dB throughout each seating section. Coverage at 4 kHz should be no more than +/- 3 dB.
4. Record the setting of each amplifier in the Project Record Manual and keep backup copies of the data file on disk.
5. After setting the amplifier level for each system, play a pink noise signal over the speakers and walk through each area. Using a sound level meter, identify any areas where the SPL changes by more than 3 dB.

H. Video System and Projector Adjustment:

1. Provide temporary video and XGA resolution computer graphic sources for testing of display.
2. Connect temporary sources to each input and confirm proper resolution and display.
3. Adjust lenses to fully fill screen with the projected image, with no exposed screen edges.
4. Adjust contrast, keystone, brightness and color for artifact free display from all inputs.
5. Test and confirm proper remote control functions from the handheld remote.
6. Measure and record visual carrier at each TV drop outlet. Rework as required to meet performance specifications.
7. Visually inspect each display for proper function and ensure display is free of artifacts. Correct anomalies.

3.5 TEST EQUIPMENT

- A. Provide the following equipment on site for final acceptance testing. Test equipment to be available for the entire period through final system acceptance unless noted. Prior to start of testing, provide a list to the Owner of test equipment make and model numbers that will be used.

1. Dual-trace Oscilloscope: 100 MHz bandwidth, 1 mV/cm sensitivity.
2. Sound Level Meter: ANSI S1.4-1971 Type SIA with digital or analog display. Meter to provide ranges of 40 to 120 dBA.
3. Pink Noise Source: Equal energy per octave bandwidth 20 Hz to 20,000 Hz, ~1 dB (long-term average) at 0 dBm output.
4. Impedance Meter: Capable of testing audio lines at a minimum of three frequencies between 250 Hz and 4K Hz. Measurement range 1 ohm to 100K ohms.
5. Multimeter: Measurement range DC to 200 Hz, 100 mV to 300 V, 10 mA to 10 A.
6. Audio Oscillator: Bandwidth 20 Hz to 20K Hz + 1 dB at 0 dBm output. Output to be balanced.
7. Oscillator to include adjustable output level.
8. Broadband RF Analyzer: WaveTek.
9. Video Analyzer: Sencore SL753D.
10. Ladders and scaffolding necessary to inspect ceiling mounted equipment, speakers, and clusters.

- B. The following procedures will be performed by the Consultant on each system:
1. Audio fidelity test: Drive the system with pink noise and measure the frequency response in each 1/3 octave band from 40 Hz to 16k Hz. Use 1/6 octave, 1/3 octave, or parametric filters to adjust the response of the system to fit the requirements of the space.
 2. Control functions shall be checked for proper operation, from controlling devices to controlled devices.
 3. Video systems shall be checked for proper operation and visual quality. All video displays shall be free of hum, distortion, and detrimental artifacts.
 4. Adjust, balance, and align equipment for optimum quality and to meet the manufacturer's published specifications. Establish and mark normal settings for each level control, and record these settings in the System Operation and Maintenance Manual.
 5. Inventory installed and loose equipment to confirm correct quantity.
 6. Any other tests on any piece of equipment or system deemed necessary.
- C. In the event the need for further adjustment or work becomes evident during equalization or acceptance of testing, the Contractor will continue his work until the system is acceptable at no addition to the contract price. If approval is delayed because of defective equipment, or because of failure of equipment or installation of equipment to meet the requirements of this Specification, the Contractor will pay for additional time and expenses of the Architect at the Architect's standard rate in effect at that time during any extension of the acceptance testing period.

3.6 TRAINING

- A. Provide training as follows:
1. Two days during commissioning period for maintenance staff.
 2. Two days with user group one week prior to initial handover to users.
 3. One day with user group and maintenance staff one month after initial training.
 4. One day with user group and maintenance staff one year after initial training, but prior to warranty expiration.
- B. Training shall include, but not be limited to:
1. Safety precautions.
 2. Identification of all elements provided under this section.
 3. Maintenance, diagnostics and trouble shooting.
 4. Operation of system, including necessary software training.
 5. Operations and maintenance manual orientation

END OF SECTION 274116

SECTION 274143 – CLASSROOM AUDIO VISUAL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

- A. Furnish and install complete Class Room Audio Visual System for each class room indicated on drawings using the Extron Electronics, Inc. Wall Vault System as basis of design.
- B. Furnish and install all equipment, accessories, and material in accordance with these specifications and drawing to provide a complete and operating System.
- C. All bids shall be based on the equipment as specified herein. The model designations are that of Extron Electronics, Inc.
- D. This section covers the requirements for an Integrator to design, provide equipment for, and install instructional classroom technology. This is intended to supply a complete instructional technology classroom that can be arranged in multiple configurations. There will be a multimedia display as primary projection. Flexibility, integration of multiple technologies and sources, and multiple user groupings are essential to this concept. As an example, all audio and image sources should be capable of being shown on the screen and heard in the classroom. The work covered in this document consists of furnishing all labor, material and services necessary to install a complete audiovisual system as indicated on the project drawings and in these specifications.

1.2 SYSTEM DESCRIPTION

- A. Provide a complete Audiovisual System for small to medium sized classrooms. The system switching and audio amplification equipment shall be securely mounted and concealed in an enclosure mounted in close proximity to the display device. Audio and image source equipment can be connected to the system and displayed via four, active (powered) interface panels located throughout the room. The audio and image signals from source devices shall be transmitted from the active interface panels over standard UTP cabling architecture.
- B. Classroom Definition: A classroom that has fixed instructional media video projection capabilities, Internet connectivity at the teacher's station, student networking (usually wireless), a document camera, VCR/DVD and/or other multimedia input devices, standard laptop interface, multimedia control system that is connected to the network and capabilities for additional add-on modular features.

- C. Technology Enhanced Classrooms (TECs) use standardized control/interface systems and employ a standardized operational protocol. The principles of this recommendation are to establish desirable goals with respect to classroom design and installed technology. The TEC classroom standard includes control systems that have ADA, Section 508 compliant buttons that are discernible without activating the controls or buttons on the control panel, easily reached control panel locations, closed captioning, hearing assistance capability, and user-friendly operator protocols among the features that are consistent with universal design principles.
- D. The room will be equipped with a standard easy to operate interface (a tactile button keypad layout). The audio system may be monaural or stereo for program sound. The instructional media system will be controlled by a control system with a control panel mounted near the instructor area. System parameters can be monitored, administered and controlled over the data network. The instructional media equipment will be located within close proximity to the instructor area or through a Graphical User Interface (GUI) on a computer to allow for ease of operation during instruction.

1.3 PERFORMANCE REQUIREMENTS

- A. Minimum acceptable functionality requirements are listed below categorized by type of equipment. Quantities are listed for movable, portable or loose equipment, and other selected entries. Where quantities are not listed, refer to the system drawings.

1.4 ACTION SUBMITTALS

- A. Product Data: Prior to ordering materials or commencing any construction activities, the Integrator shall provide the Owner with a complete bill of materials, including all quantities of components, devices, equipment, and wiring required to complete this work. Submit product data, including manufacturer's data sheets for all proposed system components. Submit three copies with all specific items that will be provided clearly indicated and any options highlighted.
- B. Shop Drawings: For system. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Show fabrication and installation details for each device and piece of equipment.
 - 2. Functional Block Diagram: Show single-line interconnections between components for controller and distribution system to user-interface points. Show cable types and sizes.
 - 3. Wiring Diagrams: For power, signal, and control wiring. For UTP or other cable, include cross connects, patch panels, and patch cords.
 - 4. Shop drawings shall be prepared by person trained and certified by manufacturer and must be approved by manufacturer prior to submitting them to Architect.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer or System integrator.
- B. Maintenance Data: For splices and connectors to include in maintenance manuals.

- C. Coordination Drawings: Include dimensioned plan and elevation views of components and enclosures. Show access and workspace requirements.
- D. Equipment List: Include each piece of equipment and include model number, manufacturer, serial number, location, and date of original installation. Insert testing record of each piece of adjustable equipment, listing name of person testing, date of test, and description of as-left set points.
- E. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 QUALITY ASSURANCE

- A. Installer or System integrator Qualifications: Installer or System integrator must be an authorized reseller or dealer of Extron Electronics, Inc. and must be trained and certified by manufacturer for installation of units required for this project.
- 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. All products shall be new and under warranty at the time of installation. B-stock, previously installed, refurbished or used equipment shall not be accepted.
- D. Where the specification lists several manufacturers for a major item, or group of items, the AV Integrator shall provide that entire item from one manufacturer only.
- E. The Integrator shall provide all options, accessories and hardware necessary to meet the function of the design even if they are not specifically listed (i.e. mounting kits, separate or additional power supplies, input modules, transformers, etc.).
- F. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- G. Grounding: Comply with ANSI-J-STD-607-A.

1.8 PROJECT CONDITIONS

- A. Environmental Limitations: System components shall be equipped and rated for the environments in which they are installed.

1.9 COORDINATION

- A. Coordinate size and location of raceway system and provisions for electrical power to equipment specified in this Section.

PART 2 - PRODUCTS

2.1 MOUNTING

- A. The audio, video, data connectivity components and projector if applicable shall be mounted using the following components.
1. Wall mount ultra-short throw projector mount and bracket shall be furnished with the owner furnished projector installed by contractor.
 2. Ceiling mount projector mount and bracket shall be owner furnished and installed by contractor.
 3. Multi-Product Plenum Mounting Kit
 - a. The multi-product plenum mounting kit houses the key electronic components of the A/V system including the switcher, audio amplifier and power supply. The kit shall mount components above a suspended ceiling, isolating them from the plenum space, and protect them from tampering and theft. Extron PVM 220.
 - b. UL listed for use in plenum airspaces. Meets UL 2043 for heat and smoke release.
 - c. Integrated fan with thermal control module, dedicated air channels, and unique enclosure design features use room side air to keep components cool and extend their operating life.
 - d. Designed to fit in a 2' x 2' style suspended ceiling and is only 6.34" deep for installations with limited space or obstructions above the ceiling.
 - e. Hinged room-side door with removable mounting plate simplifies equipment installation, setup, and maintenance.
 - f. Four integrated AC outlets provide power access to AV components.
 - g. Accepts trimmed ceiling tile to match the appearance of adjacent tiles and room environment.
 - h. Safety tether prevents door from accidentally swinging completely open.

2.2 MEDIA SOURCE SWITCHING

- A. System source selection and switching shall be provided by a PVS 405D Switcher.
1. The switcher shall have two (2) inputs that each support connection to a dual input switching wallplate via one (1) female RJ-45 connector.
 2. Audio for switched video sources shall be carried on the same RJ-45 connections.
 3. The switcher shall have a switched auxiliary audio input to support audio from video sources that are directly connected to the projector or sources that only offer audio content.
 4. The switcher shall have one HDMI video output.
 5. Connection from the switcher to the display device shall be provided with one HDMI to HDMI video cable.
 6. An onboard audio amplifier shall provide gain / volume adjustment from -10db to +10db, adjustable in 1 db steps. The speaker amplifier shall have two (2) channels, one (1) stereo (default) or dual (2) mono channels via one (1) 5.0 mm 4 pole captive screw connector. The output of the amplifier shall be 25 watts (rms) per channel at 4/8 ohms.

7. In addition to the stereo / mono speaker output, an additional audio output that will produce line level output shall also be available. This line level audio output must be capable for being set at either "fixed" or "variable" and with Balanced or Unbalanced settings.

2.3 MEDIA SOURCE CONTROL

A. Classroom media sources shall be controlled with a MediaLink Controller.

1. The MediaLink Controller shall contain six tri-color, multi-status LEDs push-buttons for device selection and projector on / off control. A rotary volume control knob with five (5) LED volume indicators shall permit system volume level control.
2. The MLC Controller shall feature Extron IP Link Ethernet for monitoring, scheduling and control. This IP technology shall enable the device to be controlled, scheduled and monitored over a LAN, WAN or the Internet using Extron Global Viewer or MLC controller software.
3. The Controller shall contain a serial host port which shall consist of one (1) bi-directional RS-232 front panel 2.5mm mini stereo jack. This host connection port shall be for configuration and control of the controller itself and to install device drivers for the equipment to be controlled.
4. The Controller shall also feature (2) bi-directional serial ports to provide device control. These two ports shall control the display device and PVS Switcher respectively via bi-directional RS-232 control via one (1) 3.5mm direct insertion captive screw connector.
5. The MLC Controller shall also have two (2) configurable (via software) digital input / outputs for devices such as sensors, switches, LEDs and relays via one (1) 3.5mm 4-pole direct insertion captive screw connector.
6. Connection from the MLC Controller to the display shall be provided by one (1) 50' Projector control cable.
7. Connection from the MLC Controller to the PVS Switcher shall be provided by one (1) 50' Switcher Control cable.

2.4 AUDIO & SPEECH REINFORCEMENT

A. Speakers: In surface wall mounted applications, One (1) pair of Extron SM3 speakers are used in all typical classrooms and (2) pairs are used in larger science labs.

1. 1-way, full range, indoor surface mount speakers; Plastic, trapezoidal, with molded grille and front bass reflex port enclosure with 0 and 10 degrees wall mounting plates.
2. Driver is (1) 3" (76.2 mm) paper cone.
3. Meeting the regulatory compliance safety specifications of NFPA90A, NFPA70; meets UL 1480 for commercial and professional audio
4. The speakers feature a frequency response of 75 Hz to 18 kHz, -10 dB, full space.
5. The power capacity is 15 watts (rms) continuous pink noise (per IEC 60268-5) 30 watts (rms) continuous program media.
6. The nominal impedance is 8 ohms.
7. The input connector uses 2 recessed pins, (1) 10 mm Euro-style captive screw terminal block, 2 pole.

8. Connection from the PVS switcher to the SM3 speaker is provided by Plenum rated 18 Gauge Speaker Cable Extron SPK-18.

B. VoiceLift Wireless IR Microphone:

1. The integrated wireless microphone is lightweight and designed to be worn around the neck with a lanyard or clipped on the belt or lapel. The instructor's voice is picked up by the microphone and transmitted wirelessly to the receiver mounted on the ceiling near the center of the room or on an unobstructed wall. The signal is then passed to the line level aux mix input of the amplifier. This is used to amplify the sound level in the classroom up to approximately 15 dB above ambient room noise.
2. Speech is mixed with the program audio and distributed out of the four (4) each speakers for even room coverage. Each microphone shall have volume control, a power switch and an auxiliary input to use for a MP3 player or other audio source. The IR microphone system can operate on two IR frequencies.
3. The microphone will have an instant alert feature that may be configured to allow the instructor to request assistance in the classroom.

C. VoiceLift Wireless IR Receiver:

1. The receiver has a round base with dome shaped translucent cover. This allows for surface mounting on the ceiling and concealed wiring above the ceiling using plenum rated cables run to the dedicated VoiceLift Receiver input of the PVS Switcher.
2. This device acts as the receiver of up to two room microphones and transmits their audio signal to the PVS Switcher for mix into the program content of presented material. The receiver has a contact closure that when wired and configured to the digital input of the MLC, can trigger instant alert messages to a designated text or email account.

D. VoiceLift Wireless IR Microphone Charging Station:

1. This device is constructed of high impact ABS plastic and acts as a holding and charging station of up to two of the Extron VoiceLift wireless IR microphones. It ships with its own power supply that acts as a recharging station for the two microphones.

2.5 MEDIA SOURCE INTERFACING

- A. The media source equipment shall be connected to the audiovisual system via two to four (2-4) Active (powered) Twisted Pair Transmitter Wall Plates. These wall plates shall enable the system to display video, graphic data and audio from Laptop computers, DVD and VCRs, document cameras, camcorders, etc.
- B. These active interface transmitters shall be placed in convenient locations throughout the classroom to facilitate easy connection of sources.
 1. Two PVT RGB D, VGA Video Twisted Pair Transmitter - Wall Plate shall be used to connect RGB devices to the system and transmit the video and audio data to the PVS switcher.

- a. The Active Twisted Pair Transmitter shall transmit RGB video over UTP cable to the PVS Switcher and support video input resolutions of VGA - UXGA RGBHV, RGBS, RBsB and RsGsBs via one (1) female 15-pin HD connector.
 - b. Wall plate shall fit in a standard, single-gang electrical box and feature Decora® type faceplates.
 - c. Stereo audio shall be input via one (1) 3.5 mm mini stereo jack.
 - d. The output of the interface shall be via two (2) female RJ-45 connectors.
 - e. Connection to the PVS Switcher shall be via two (2) UL plenum rated UTP cables.
2. Two DTP HDMI 230 D Tx, HDMI Video plus control and analog audio Twisted Pair Transmitter – Wall Plates shall be used to connect HDMI video devices to the system and transmit the video and audio data to the projector via a set of two DTP HDMI 230 Rx receivers and one SW2 HDMI switcher.
 - a. The Active Twisted Pair Transmitter shall transmit HDMI video and embedded audio over UTP cable to the corresponding DTP HDMI 230 Rx receiver and support digital video / audio input via a HDMI connector.
 - b. Wall plate shall fit in a standard, double-gang electrical box and feature Decora® type faceplates.
 - c. Analog audio input available on the faceplate is not used in this case.
 - d. The output of the interface shall be via one (1) female RJ-45 connector.
 - e. Connection to the HDMI receiver shall be via one (1) UL plenum rated UTP cable.
3. Two DTP HDMI 230 Rx, HDMI Video plus control and analog audio Twisted Pair Receiver – shall be used to receive HDMI video and embedded audio from corresponding DTP HDMI 230 D Tx, transmitter over UTP cable and connect to a SW2 HDMI switcher over HDMI cable.
 - a. The Active Twisted Pair Receiver shall receive HDMI video and embedded audio over UTP cable from the corresponding DTP HDMI 230 D Tx transmitter and support digital video / audio input via a HDMI connector.
 - b. The receiver shall be housed in the wall vault system multi-product mounting kit.
 - c. The output of the receiver to the HDMI switch shall be via one (1) HDMI cable.
4. One SW2 HDMI, Two input HDMI switcher – shall be used to receive HDMI video and embedded audio from two DTP HDMI 230 Rx receivers over HDMI cable and shall provide a single HDMI output to the projector a SW2 HDMI switcher over HDMI cable.
 - a. The receiver shall be housed in the wall vault system multi-product mounting kit.

2.6 DATA CONNECTIVITY

- A. The audio video system shall include a IP Link enabled MediaLink controller that allows remote monitoring, scheduling and control of the system over a network.

2.7 ENERGY EFFICIENCY

- A. The audio video system shall incorporate energy conservation features to reduce consumption and lower operating costs.
 - 1. The system shall incorporate an Auto Power Save Mode with fast power-up that automatically deactivates the audio amplifier after 30 minutes of inactivity. It quickly returns to full power status in less than one second upon signal detection
 - 2. The system shall incorporate a Standby Mode that allows the amplifier and twisted pair transmitters to be deactivated when not in use.
 - 3. The system shall incorporate monitoring and scheduling of system peripherals, such as sources and displays, in order to deactivate them when not in use or alert to unauthorized use.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Site Verification of Conditions: Verify that related conditions, including equipment that has been previously installed under other sections, are acceptable for product installation in accordance with manufacturer's instructions.
- B. All devices connected to equipment specified in this section shall bear the UL label and comply with the applicable National Electrical Code (NEC) standards.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. General:
 - 1. All equipment and enclosures described in this specification shall be installed plumb and square per manufacturer's instructions.
 - 2. All equipment, except that designated as movable, portable or loose equipment, shall be secured and permanently attached to the permanent structure in a manner which will require the use of a tool (e.g.: screw driver, nut driver, etc.) for removal.
 - 3. All supports shall meet or exceed the load requirements of the intended application with a minimum safety factor of five.
 - 4. Provide support structure and hardware with a SAE Grade 8 load rating (min.).
- B. Integrator shall furnish all equipment, labor, system setup, and other services necessary for the proper installation of the products/system as indicated on the drawings and specified herein. System setup information shall include each components proper mounting and alignment and properly verified signal pathways and operation. Proper operational and network support control functions shall be verified.
- C. Install in accordance with manufacturer's handling and installation instructions.

- D. Install in accordance with all local and pertaining codes and regulations.
- E. Utilize an Integrator with demonstrated experience in projects of similar size and complexity.
- F. Equipment shall be configured and in ready to use condition at the end of installation.
- G. Energize and commission equipment in accordance with manufacturer's instructions. Commissioning the system shall at minimum, consist of the following:
 - 1. Install Global Configurator software on PC, download from www.extron.com, or install from Extron Software Products CD.
- H. Make the following MLC cable connections:
 - 1. Power.
 - 2. Local Area Network (LAN).
 - 3. Classroom Source Devices.
- I. Program and Configure system, installation of the Extron system is covered in full detail at <http://www.extron.com/training/index.aspx>:
 - 1. Configure MLC 104 IP Plus Series using Global Configurator.
 - 2. Download device drivers for all source and projection devices.
 - 3. Create a new Global Configurator project file.
 - 4. Add a device and set its IP address.
 - 5. Define the location of the new Media Link Controller device.
 - 6. Save the new Global Configurator file.
 - 7. Configure e-mail server.
 - 8. Configure e-mail messages.
 - 9. Configure contacts.
 - 10. Assign serial device drivers.
 - 11. Assign IR drivers.
 - 12. Configure the front panel (All buttons are required to have a function assigned: source or control).
 - 13. Configure associated control modules.
 - 14. Create a shutdown schedule.
 - 15. Create a lamp hour notification.
 - 16. Create a disconnect notice.
 - 17. Build the Global Configurator file.
 - 18. Upload the Global Configurator file.
 - 19. Launch GlobalViewer.
 - 20. Test the MLC's setup for proper control and support of the classroom.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

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. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
- C. Components and system will be considered defective if they do not pass manufacturer recommended tests and inspections.
- D. Repair or replace damaged components before Substantial Completion of the project.
- E. Remove temporary tags, coverings, and construction debris from interior and exterior surfaces of the equipment. Remove construction debris from equipment area and dispose of properly.
- F. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for troubleshooting, servicing, and maintaining equipment.
 - 2. Demonstrate methods of determining optimum alignment and adjustment of components and settings for system controls.

END OF SECTION 274143

SECTION 275113 - PAGING SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY OF WORK

- A. It is the intent of this Section in conjunction with the applicable Drawings is to provide specifications for a complete and functional system. All locations, as detailed on the Drawings, shall be tested and balanced as to provide a reasonable level of volume to accommodate the paging needs of the school. This includes classrooms, administrative and general areas as well as the Commons, Gymnasium and, where specified, exterior areas of the building.

1.2 WORK INCLUDED

- A. Provide all labor, materials, tools, and equipment for a complete and operational overhead paging system as called for in the specifications and Drawings, specifically:
 - 1. Public address system amplifiers, zone controls, back boxes, and all equipment, cabling and support required to interface the Public Address System to the Owner's Telephone System (Not included in this contract).
 - 2. Public Address System Speakers, ceiling mounted, wall mounted horn, both interior and exterior.
 - 3. Volume attenuators where shown on the drawings to adjust the PA speaker sound level.
 - 4. Messaging calendar clock capable of receiving and scrolling up to 64 character custom messages without affecting or replacing display of time segments.
 - 5. No call boxes, one way paging only. Call backs will be via the phone system.
 - 6. Interactive Graphical User Interface (IGUI) to intercom functions including zone or all page, selecting and distributing program sources to predefined zones or all zones and facilitating single action activation of multiple system interface e.g. access control and CCTV or other systems as directed by Owner.

1.3 QUALITY ASSURANCE

- A. The Contractor shall currently maintain a locally run business for a minimum of five years and shall be an authorized distributor of the supplied equipment with full warranty privileges.
- B. The Contractor shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the equipment manufacturer to maintain and service the equipment being supplied.
- C. Contractor shall have attended the manufacturer's installation and service school.

- D. The Contractor shall furnish manufacturer's manuals of the completed system including individual specification sheets, schematics, inter-panel and intra-panel wiring diagrams. In addition, all information necessary for the proper operation of the system must be included. Any bidder using other than the specified equipment must provide this information prior to bidding.
- E. As built drawings that include any changes to wiring, wiring designations, junction box labeling and any other pertinent information shall be supplied both electronically in AutoCAD® 2010 (or later) and as a full size (30" x 42") drawing upon completion of project.

1.4 IN SERVICE TRAINING

- A. The Contractor shall furnish a minimum of four hours of in service training with the system. These sessions shall be broken into segments that will facilitate the training of individuals in operating station equipment, administrative devices, user programming functions, and program distribution equipment. Operating manuals and users guides shall be provided at the time of the training.

1.5 MAINTENANCE SERVICE

- A. The Contractor shall provide a one-year guarantee of the installed system against defects in material and workmanship. All labor and materials shall be provided at no expense to the Owner. Guarantee period shall begin on the date of acceptance by the Owner or engineer.
- B. A maintenance contract offering continued factory authorized service of this system shall be made available if requested by the Owner.

1.6 SUBMITTALS

- A. Data sheets shall be provided on all equipment being provided.
- B. Internal control cabinet drawings showing internal block diagram connections shall be provided.
- C. Wiring diagrams, detailing wiring for power, signal, and control, differentiating clearly between manufacturers installed wiring and field installed wiring. Identify terminals to facilitate installation, operation and maintenance.
- D. Provide a riser diagram for the system showing in technically accurate detail all connections, interconnections, and all provisions available and made for adaptability of all specified future functions and including all calculations, charts, and test data necessary to demonstrate that all systems and system components deliver the specified signals, grades, and levels at all required points and locations.

1.7 REGULATORY REQUIREMENTS

- A. The entire installation shall comply with all applicable and safety codes. All central equipment and additional applicable equipment shall be listed by Underwriters' Laboratories, per US requirements. Note: Furnish an original, dated specimen of the test agency's listing card with the submittal.
- B. All equipment with digital apparatus (microprocessors) that generate and use timing signals at a rate in excess of 9,000 pulses per second to compute and operate must be Federal Communications Commission (FCC) and DOC CSA standards C108.8 (Electromagnetic Emissions) compliant. Any non-compliant equipment supplied or installed shall not be accepted and shall nullify the contract. Note: Provide documents supporting and verifying compliance.
- C. Systems shall be considered non-compliant unless they completely meet the criteria as outlined in this section. All supporting documentation shall be included as part of the initial submittal package. Letters regarding "future approval" or "approval pending" shall not be considered.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Rauland: TELECENTER U Series paging system. No substitutions.

2.2 GENERAL

- A. All materials and equipment installed under this contract shall be new, unused, free of defects, and of current manufacture. Equipment and material shall carry Underwriters Laboratory (UL®) certification if required by local, state or national codes.
- B. The installation shall include a comprehensive programmable microprocessor based communications system consisting of a central switching exchange capable of handling up to 32 paging zone groups each capable of 99 zones.
- C. Interface with clock system for time synchronization.
- D. The central switch shall utilize standard dual tone multi-frequency type decoding (DTMF) for conformance with standard telephone practices.
- E. Provide an amplifier circuit for each of the paging zones. Provide separate paging zones as shown on drawings.
- F. Provide eight (8) separate time-tone schedules with a minimum of 1024 events. Individual events of each schedule shall be capable of sounding one of nine user defined tone types. These schedules can be run individually or simultaneously.

- G. Provide eight (8) internal relays which can be activated manually from any administrative phone or automatically via an optional integral Master Time Control Center.
- H. Program distribution of audio program sources to any one or group of paging zones.
- I. System shall be capable of nine (9) built in software definable signaling tones.
- J. Two (2), three (3) or four (4) digit programmable zone numbers for paging zones.
- K. Integral internal program clock for time tone distribution and other time related functions. It shall be possible to synchronize the program clock from an external master clock.
- L. Pre-announce tones will alert the listeners of incoming calls with distinct tones for each priority level. To prevent unauthorized monitoring, the tone will sound whenever an area is being monitored, and will repeat at regular intervals. Facilities shall also be provided to defeat the tone repeat function from the console if it is not desired.
- M. Emergency and All Call paging and a minimum of 32 zones of group paging - The paging zones shall be independent of the time tone and audio program distribution zones and a minimum of 8 clock messaging zone. Systems sharing zones for both paging and tone shall not be acceptable.
- N. The paging speaker shall be 8" or 6" as defined below with integral transformer assembly. Provide with metal baffles and enclosures
- O. Gym and Commons area speakers to be equipped with vandal resistant baffle.
- P. Weatherproof outside paging loudspeakers shall have a minimum power rating of five (5) watts. The speaker shall have a minimum frequency response of 80-10KHz and a dispersion angle of 120 x 60 degrees.
- Q. It shall be possible to distribute paging, time tone class change, or emergency signal to all classrooms and (8) additional specific paging zone groups of rooms as programmed into the system software.
- R. Program sources for distribution shall be:
 - 1. An Owner provided MP3 player.
 - 2. Provide a Music input along with the emergency microphone located in the Main office.
- S. All programmable functions shall be located in battery backed ram to prevent loss in a power failure condition

2.3 PRE-APPROVED COMPONENTS

- A. System shall be based on Ashly Protea software, IP paging speaker clock combination devices with two-way microphone, analog speakers, analog horns, line level interface modules and 2-channel amplifiers.

2.4 INTERCOM SPEAKERS

A. IP Intercom Speaker Digital Clock Combination Device: (CLASSROOM SPACES SYMBOL IS THE LETTER "I" WITHIN A BOX)

1. Intercom digital clock speaker shall be IP enabled with an 8-pin modular connection and shall be powered utilizing Power-over-Ethernet (PoE). The speaker shall have an internal microphone with the capability for two-way communication utilizing an omni-directional subminiature electret condenser microphone.
2. The device shall contain a factory assembled loud speaker, LED readout with dot matrix 32x8 display and 40 LEDs per character for the clock and text messaging notification in the color red, baffle and PCB amplifier.
3. The amplifier shall provide 9 watts into the 8 ohm loudspeaker with 9 volt DC minimum power from the Ethernet PoE switch. Loudspeaker shall be dual cone 8 inch with a 10 ounce ceramic magnet. Provide back box enclosure for flush mount and surface mount installations. Back box enclosure for surface mount conditions shall match the color of the speaker grill.
4. Coordinate color of the device with Architect's interior designer.
 - a. Approved is Atlas Sound, Part No. I8SCM+ or Rauland equal.
5. Backbox for IP Intercom Speaker Digital Clock Combination Device:
 - a. Flush Mount Straight Enclosure, Atlas Sound Part No. FEST-I8SC or Rauland equal.
 - b. Surface Mount Straight Enclosure, Atlas Sound Part No. SEST-I8SC or Rauland equal.

B. Interior Intercom Analog Speakers: (GENERAL PAGING SPEAKER SYMBOL IS THE LETTER "P" WITHIN A BOX)

1. Interior speakers for wall mount and ceiling mount applications shall be 8-inch permanent magnet cone-type having a viscous-damped cone and a ceramic magnet weighing a minimum 10-ounces. The speaker assembly shall be equipped with a dual-winding, 25 volt/70 volt line matching transformer. Transformers shall provide 0.5, 1 and 2 watt power taps for both 25 volt and 70 volt operation. The speaker assemble shall include a CRS white powder coated baffle with concealed loudspeaker mounting studs and includes screw mount hardware.
 - a. Speakers in Gym:
 - 1) Speaker: Atlas Sound, Part No. FD72W or Rauland equal.
 - 2) Enclosure: Atlas Sound, Part No. CS95-8 or Rauland equal.
 - b. Speakers in Classrooms:
 - 1) Speaker: Atlas Sound, Part No. FA136 or Rauland equal.
 - 2) Grill: Atlas Sound, Part No. FA51-6 or Rauland equal.
 - 3) Tile Bridge: Atlas Sound, Part No. FA81-6 or Rauland equal.
 - 4) Enclosure: Atlas Sound, Part No. FA95-6 or Rauland equal.

C. Ceiling Mounted Speaker Enclosures:

1. Enclosures for ceiling installations shall include pre-mounted brackets, attachment hardware, and support rails. It shall be capable of transferring the combined weight of the loudspeaker assembly to the ceiling's support members via adjustable rails.

Unit shall be of welded steel construction, finished in textured black epoxy, and be undercoated to guard against acoustical and mechanical resonance. Unit shall also be equipped with conduit knockouts.

- a. Approved is Atlas Sound, Part No. EZ96-8 interior drop ceiling or Rauland equal.

D. Exterior Intercom Weatherproof Vandal Resistant Speaker: (WALL MOUNT EXTERIOR SPEAKER)

1. Exterior speakers for wall mount applications shall be installed on the exterior of the building, and shall be horns with back boxes and cast metal grilles. The loudspeaker shall be of the flush mount weatherproof type and all exposed metal parts shall be heavily plated and sealed.

- a. The loudspeaker shall have a full range audio power rating of 15 watts. A rubber gasket for providing a weatherproof seal between speaker flange and mounting surface shall be furnished.

2. The loudspeaker shall have an integral transformer capable of delivering its full rated power within +1.0 dB, 100 Hz to 10 kHz. The primary taps shall have power taps of 5, 2.5, 1.25, .625 and .3125 watts. The secondary impedance shall be 8 ohms.

- a. Approved is Rauland ACC1411 with ACC1105 Flush mount square back-box.

E. Vandal-Proof Exterior Grille / Enclosure:

1. Provide vandal-proof exterior speaker grille. The square front of the grille shall be manufactured from a special self-aging aluminum alloy which has a tensile strength of 44,000 psi. Each grille shall have a heavy gauge cold rolled steel perforated screen to protect the speaker from vandal damage. The four mounting holes shall be counter sunk.
2. The grille shall be furnished with tamper proof hardware to prevent unauthorized entry to the grill interior. Coordinate with Architect to match the exterior finishes of the structure. The flush enclosure shall be constructed of 18-gauge stainless steel.

- a. Approved Rauland ACC1411 with ACC1105 Flush mount square back-box and carbon steel baffle.

2.5 INTERCOM AMPLIFICATION AND CONTROLLERS

A. Intercom Paging Amplifier:

1. Provide high power dual channel amplifier with channel separation and low distortion, capable of supporting two channels. Amplifier shall be flexible in providing wattage outputs from 160 watts to 600 watts based upon the configuration selection.
2. Amplifier shall have stepped attenuators to provide gain setting repeatability, rear mounted barrier strips for inputs and outputs and XLR input connectors. Amplifier shall be capable of providing stereo, bridge or parallel operating modes and 25 volt, 70.7 volt, 100 volt and direct coupled 2, 4 and 8 Ohm outputs. Amplifier shall have independent power supplies and shall be rack mounted in a three rack unit dimension.
 - a. Basis of design is Ashly NE Series and Ashly NX series, or approved equal.

B. Intercom Zone Controllers:

1. Provide intercom zone controller to provide an IP addressable end point connection for a series of analog speakers or connection to existing analog intercom headend cabinets for line level audio output. Controller shall be capable of supporting 25 volt, 70.7 volt or 100 volt speakers or paging horn devices.
2. Controller shall provide connections to paging amplifiers that support analog speakers in a total distance of 328 feet. The controller power shall be PoE and the output shall be a balanced line level with a 3 pole terminal block located at the rear of the controller.
3. Controller shall be rack mounted in a one rack unit dimension.
4. Provide one controller for each zone and connect to the corresponding paging amplifier.
 - a. Basis of design: Rauland:
 - 1) Rauland TCC200
 - 2) Rauland TCC2022
 - 3) Rauland TCC2033
 - 4) Rauland TCC2099
 - 5) Or approved equal

C. Administrative Console:

1. Console provides a single point for administration of paging functions.
 - a. Basis of design Rauland TCC2044 or approved equal.

2.6 LAN/WAN CONNECTIVITY

- A. Controller access and operation shall be one hundred percent compatible with IEEE 802.3 Ethernet and be equipped a LAN port for offsite programming and diagnostics.
- B. System must have the capability to add optional remote stations / power supplies with LAN connectivity to main controller. Basis of Design: Rauland TCC2055 or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Complete system shall be installed in strict accordance with manufacturer's recommendations.
- B. All wiring shall be installed in raceways or plenum rated, where routed through plenum ceiling areas.
- C. Each IP intercom speaker clock device shall be connected to the horizontal crossconnect in a telecommunications room with horizontal cabling installed in a star topology.
- D. Horizontal cabling shall be installed in continuous runs from the Telecommunications Rooms to the IP intercom speaker clock device locations. Splices are not permitted.
- E. All cable shall be as per manufacturer specification.
- F. Provide connection to the access control panel for distribution of emergency tones associated with lockdowns, etc.

3.2 DISTRICT COORDINATION

- A. Contractor shall be responsible for coordination of all IP address requirements with District.
- B. Contractor shall coordinate all routing and firewall requirements and verify proper operation with District IT staff.

3.3 INSPECTION AND TEST UPON COMPLETION

- A. Check-out and final connections to the system shall be made by a factory trained technician in the employ of a manufacturer of the products installed. In addition, factory trained technicians shall demonstrate operation of the complete system and each major component to the Owner. At a minimum, the following must be demonstrated:
 - 1. Paging of each zone to verify volume and clarity of message
 - 2. Synchronization of clocks, bells and paging to same (exact) time
 - 3. Paging from telephone handsets from any location within the school
 - 4. Ability to program multiple, different schedules for bells to heard throughout he buildings speakers and horns
 - 5. Remote access capability
- B. System field wiring diagrams shall be provided to this subcontractor by the system manufacturer prior to installation.
- C. All materials and installation shall be guaranteed to be free of defects in material and workmanship for one year after final acceptance of installation and test.

- D. As-built drawings: 3 sets. They should include up-to-date drawings that include any changes made to the system during installation. Circuit diagrams and other information necessary for the proper operation and maintenance of the system shall be included. Drawings must be provided on CD in AutoCAD® 2010 format.
- E. Upon completion of the installation, four (4) copies of complete operational instructions shall be furnished, complete with record drawings. Instructions shall include part numbers and names, addresses, and telephone numbers of parts source. Final payment shall not be made until operational manuals have been received.
- F. Upon completion of the installation of the equipment, the Contractor shall provide to the Owner's Representative a signed statement from the equipment supplier that the system has been wired, tested, and functions properly according to the specifications.
- G. Nothing herein contained shall be construed to relieve the Contractor from furnishing a complete and acceptable electrical wiring system in all its categories. The Owner or the Owner's Representative will condemn and reject any materials or labor which are or may become detrimental to the accomplishment of the intentions of these specifications.

END OF SECTION 275113

SECTION 275313 - CLOCK SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. NIST: The National Institute of Science and Technology.
- B. PC: Personal computer.
- C. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual, for the following:
 - 1. Master unit.
 - 2. Indicating clocks.
 - 3. Signal equipment.
 - 4. Equipment enclosures and back boxes.
 - 5. Accessory components.
- B. Shop Drawings: For clock systems. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring and correction circuits.
 - a. Identify terminals and wiring color codes to facilitate installation, operation, and maintenance.
 - b. Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from overcurrent, static discharge, and voltage surge.
 - 2. Details of seismic restraints including mounting, anchoring, and fastening devices.
 - 3. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.

1.4 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Data: Certificates, for the master clock, 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.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For clock and program control to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.2 MASTER AND SECONDARY CLOCK SYSTEM

- A. Manufacturers: Subject to compliance with requirements, provide the following system:
 - 1. PRIMEX 14000-E, no substitution.

2.3 TRANSMITTER WITH EXTERNAL ANTENNA

- A. 1-watt transmitter equipped and configured for external roof-mounted antenna.
- B. Transmitter with the following:
 - 1. 72MNz frequency range
 - 2. 16 channels abvailable
 - 3. Daylight saving time bypass switch
 - 4. Time zone adjustment switch
 - 5. LCD display for time, date, and signal verification

2.4 SECONDARY INDICATING CLOCKS

- A. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.
 - 1. Education Series with the following:
 - a. Durable thermoplastics frames and lenses
 - b. Automatic adjust for daylight savings time
 - c. Communicate with smart sync bridge via Bluetooth low energy wireless technology.
- B. Provision for Modular Panel Installation: Equip designated clock for panel mounting. Mount flush or semi-recessed with arrangement and trim as indicated. Coordinate wiring with other modular panel components, including room lighting switches, intercom devices, convenience outlets, data outlets, speaker and other similar devices.
- C. Provision for Time-Tone-Unit Installation: Equip indicated clocks for housing or mounting in an acoustically treated and baffled speaker compartment specified in Division 27."
- D. Secondary Indicating Clock Characteristics:
 - 1. Clock Type: Analog.
 - 2. Face Configuration: Single or Double.
 - 3. Mounting: Recessed, Semi-recessed, Pendant, Surface, Suspended, Within time-tone unit, or Within modular panel.
 - 4. Dial Face Color: Match existing clocks.
 - 5. Analog Clock Crystal: Clear to match existing clocks.
 - 6. Face Color: to match existing clocks.
 - 7. Display Height:
 - a. 12" GPS satellite battery operated clock in the following locations:
 - 1) Classroom
 - 2) Office

b. 16" GPS satellite battery operated clock in the following locations:

- 1) Gym
- 2) Cafeteria

2.5 BACK BOXES FOR SECONDARY INDICATING CLOCKS AND PROGRAM DEVICES

- A. Description: Box and cover-plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting the device unless otherwise indicated.

2.6 GUARDS

- A. Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.
1. Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
 2. Finish for Indoor Devices: Clear epoxy lacquer over zinc plating.
 3. For the following clock locations:
 - a. Gym
 - b. Multi-purpose area

2.7 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. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions.
- B. 120-V AC and Class 1 Signal and Control Circuits: Stranded, single conductors of size and type recommended by system manufacturer. Materials and installation requirements are specified in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 2 and Class 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable. Materials and installation requirements are specified in division 26.
- D. Data Circuits: Category 6 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.
- E. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
- F. Plenum Cable: Listed and labeled for plenum installation.
- G. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.

- H. Shielding: For speaker-microphone leads and at other locations 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.

2.8 PATHWAYS

- A. Intercommunication and Program System Raceways and Boxes: Comply with requirements in division 27.
- B. Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in division 26.
- C. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
- D. Flexible metal conduit is prohibited.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in division 27.

3.2 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in 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 division 27.
- B. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- C. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA-568-C.

3.3 ELECTRICAL CONNECTIONS

- A. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

- B. Use plug connectors for connections to clocks and signal devices.
- C. Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.4 IDENTIFICATION

- A. Comply with division 27.
- B. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
 - 2. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- C. Clock system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Program system according to Owner's requirements. Set system so signal devices operate on Owner-required schedules and are activated for durations selected by Owner. Program equipment-control output circuits to suit Owner's operating schedule for equipment controlled.
- B. Adjust sound-output level of adjustable signal devices to suit Owner's requirements.

END OF SECTION 275313

SECTION 275319 - DISTRIBUTED ANTENNA SYSTEM (DAS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This specification describes technical and performance criteria for deploying a Distributed Antenna System (DAS) capable of supporting Public Safety Networks (PSN).
- B. Prior to installation, Contractor shall confirm with AHJ if DAS is required for William Walker Elementary School. Coordinate necessary testing and site construction requirements with AHJ and Beaverton School District.
- C. The DAS components specified in this document include:
 - 1. Bi-Directional Amplifiers (BDA),
 - 2. Fiber-Optic Master Unit
 - 3. cable/remote units
 - 4. Donor Antennas,
 - 5. Coverage Antennas,
 - 6. Coaxial Cable and Coax Connectors
 - 7. Splitters, Combiners, and Couplers,

1.3 RELATED SECTIONS

- A. 270526 Grounding and Bonding for Communications Systems
- B. 270528 Pathways for Communications Systems
- C. 270528.29 Hangers and Supports for Communications Systems
- D. 271323 Communications Optical Fiber Backbone Cabling

1.4 SYSTEM DESCRIPTION

- A. Services: Upon system acceptance testing, the DAS shall provide coverage for the PSNs listed below:

<u>Service</u>	<u>Uplink, MHz</u>	<u>Downlink, MHz</u>
800 Band	806 - 824	851 - 869

- B. PSN Approval: The Contractor shall propose and deploy a DAS system capable of receiving approval of Washington County Consolidated Communications (WCCCA) which is the PSN Authority Having Jurisdiction (AHJ) - .
- C. Active Fiber DAS Distribution (If required): Single-mode fiber-optic cable shall be used for active distribution. In-line amplifiers are not allowed.
- D. Network Management:
1. NMS: The DAS shall have a Network Management System (NMS) capable of alarm, monitor, configuration and control of all Active Components of the DAS system.
 2. NMS shall also be capable of monitoring toh following:
 - a. Low battery condition on UPS
 - b. Battery charger failure on UPS
 - c. Output from UPS
 - d. Output from emergency generator
 3. The DAS Electronics shall provide the following outputs for monitoring by the Fire Alarm System:
 - a. Donor Antenna Malfunction
 - b. Signal booster Failure
 - c. Signal booster fault.
 - d. Loss of AC Power

1.5 PERFORMANCE REQUIREMENTS

A. PUBLIC SAFETY NETWORK (PSN) DAS:

1. The PSN DAS shall comply with IFC 510 {2009}{2012} and NFPA-72 2013 Edition.
2. The DAS shall deliver coverage per the criteria below throughout 95% of all occupied building spaces and 99% in critical areas as defined in NFPA 72.

<u>Parameters</u>	<u>Units</u>	<u>Public Safety 800 MHz</u>
Minimum Downlink RSL	dBm	-95

3. The DAS shall be capable of upgrade, without additional hardware or software, to allow for changes to system frequencies within the deployed frequency band in order to maintain radio system coverage as originally designed.

1.6 SUBMITTALS

A. Submittal Requirements with the Bid:

1. Certificates
 - a. A certificate from the manufacturer of the equipment to be installed stating that the DAS installer is trained/ qualified on the equipment.
2. Test Equipment
 - a. Submit certificates indicating that staff is certified on required test equipment including by not necessarily limited to:
 - 1) Signal Generators
 - 2) Spectrum Analyzers
 - 3) PIM Testers
 - b. Submit current calibration data for test equipment to be used.
3. Equipment cutsheets on any equipment proposed for substitution in compliance with Section 1.7 of the specifications.
4. Bid Assumptions
 - a. Contractors shall state the actual channel count from the local AHJ for the PSN Frequency Bands identified above with submittal of bid response. Prior to installation, contractors shall confirm the channel count and frequencies with the AHJ, and shall guarantee coverage for these channels per the criteria stated above.

B. Submittal Requirements Prior to Start of Construction

1. Statement of Work (SOW): The contractor shall submit a SOW that has been accepted by the customer or customer's designated representative.
2. Acceptance Test Plan (ATP): The contractor shall submit an ATP that has been accepted by the customer or customer's designated representative.
3. To scale floor plans showing the location of system Components.
4. Final RF link budget
5. Detail Drawings for Donor Antenna and grounding
6. Product Data Sheets for each type of equipment to be installed.
7. Maintenance Service Contract
8. Permit drawings as required by the AHJ and Letter of Authorization from WCCCA for re-transmission of frequencies.

C. Submittal Requirements at Close Out

1. Drawings: Submit as-built drawings indicating:
 - a. Donor antenna, grounding and lightning protection details
 - b. Cable routing, splitters, couplers and coverage antenna locations
 - c. Active component locations, layout and configuration

2. Test reports shall confirm the requirements of Section 1.4 have been met.
3. Cable Test Reports: Submit cable test results for all cable segments. Testing shall include Return Loss (RL), Distance to Fault (DTF) and Passive Intermodulation (PIM).
4. Field Reports: Submit test results for all fiber runs.
5. Operation and Maintenance Data: Submit hardware and software manuals for all Active Components.
6. Acceptance Certificate or Document from the AHJ
7. Warranty Documents:
 - a. Submit for all manufactured components specified in this Section.
 - b. Submit Contractor's System Warranty.
 - c. Submit Manufacturer's Warranty

1.7 SUBSTITUTIONS

- A. Contract Documents are based on equipment manufacturers as called out in the Specifications and indicated on the Drawings. Acceptance of substitute equipment manufacturers does not relieve Contractor of the responsibility to provide equipment and materials, which meet the performance as stated or implied in the Contract Documents.
- B. Submit proposals to provide substitute materials or equipment, in writing, in compliance with Bidding and Division 1 requirements.
- C. Indicate revisions required to adapt substitutions including revisions by other trades. Substitutions that increase the cost of the work for related trades are not permitted.
- D. The proposed substitution shall conform to the size, ratings, and operating characteristics of the equipment or systems as specified and shown on the Drawings.
- E. Proposals for substitutions shall include the following information:
 1. Passive Components:
 - a. Product samples
 - b. Detailed product specifications
 - c. Independent test results verifying the product specifications
 - d. Written documentation from the manufacturer guaranteeing that the alternative component(s) shall remain available for new purchase for a period of 7 years from the date of system acceptance.
 2. Active Components:
 - a. Hardware and software manuals
 - b. Detailed product specifications
 - c. Mean Time Between Failure (MTBF) data for each Active Component
 - d. Written documentation from the manufacturer guaranteeing that the alternative component(s) shall be supported for a period of 2 years from the date of system acceptance.

- e. For Active Components serving the PSN, written documentation from the AHJ that the alternative component(s) are approved for use within the PSN and that system acceptance of the DAS to the PSN shall not be withheld due to the alternative component being used in the DAS.

1.8 CODES AND STANDARDS

- A. All work shall comply with the latest editions of the *NEC*[®], National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements. Equipment and cabling installation shall comply with the following standards. All publications must be of the latest issue and addenda:

1. NFPA 70 - 2014 National Electrical Code (*NEC*[®])
2. 2009 (2012) International Fire Code
3. NFPA 72 - 2013 – National Fire Alarm and Signalling Code
4. Federal Communications Commission (FCC) - Title 47 of the Code of Federal Regulations, Part 90.
5. Federal Communications Commission (FCC) Rules, Parts 15 and 22
6. ANSI/TIA-568-D.O: Generic Telecommunications Cabling for Customer Premises
7. ANSI/TIA-568-D.1: Commercial Building Telecommunications Cabling Standard Part 1: General Requirements
8. ANSI/TIA-568-C.2: Balanced Twisted-Pair Telecommunications Cabling and Components Standards
9. ANSI/ TIA-568-C. 3: Optical Fiber Cabling Components Standards
10. ANSI/TIA-569-D: Commercial Building Standard for Telecommunications Pathways and Spaces
11. ANSI/TIA-606-B: The Administration Standard for the Telecommunications Infrastructure of Commercial Building
12. ANSI/ TIA-607 -C: Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
13. *Bicsti*[®] Information Transport Systems Installation Methods Manual, 5th Edition
14. *Bicsti*[®] Telecommunications Distribution Methods Manual, 12th Edition

1.9 ABBREVIATIONS

- A. ACG: Automatic Gain Control
- B. AHJ: Authority Having Jurisdiction
- C. ATP: Acceptance Test Plan
- D. AWS: Advanced Wireless Service
- E. BDA: Bi-Direction Amplifier
- F. BRS: Broadband Radio Service

- G. BTS: Base Transceiver Station
- H. CDMA: Code Division Multiple Access
- I. C/N: Carrier-to-Noise Ratio
- J. CW: Continuous Wave
- K. CWDM: Coarse Wave Division Multiplexing
- L. DAS: Distributed Antenna System
- M. DWDM: Dense Wave Division Multiplexing
- N. EBS: Educational Broadband Service
- O. ESMR: Enhanced Specialized Mobile Radio
- P. EOS: Electrical Optical System
- Q. FCC: Federal Communications Commission
- R. GUI: Graphical User Interface
- S. iDEN: Integrated Enhanced Digital Network
- T. LMR: Land Mobile Radio
- U. MTBF: Mean Time Between Failure
- V. NFPA: National Fire Protection Association
- W. NMS: Network Management System
- X. PCS: Personal Communications System
- Y. PSN: Public Safety Network
- Z. RoF: Radio-over-Fiber
- AA. RoHS: Restriction of Hazardous Substances
- BB. RSL: Received Signal Level
- CC. SISO: Single-Input, Single-Output
- DD. SMR: Specialized Mobile Radio
- EE. SMS: Short Message Service
- FF. SNIR: Signal-to-Noise Interference Ratio

GG. SNMP: Simple Network Management Protocol

HH. VSWR: Voltage Standing Wave Ratio

1.10 DEFINITIONS

- A. Acceptance: Expressed approval by the customer
- B. Active: DAS components that require AC/DC power for operation
- C. Carrier Approval: Expressed approval to interconnect to the WSP macro network
- D. Channel: A path for an RF transmission between two points
- E. Component: A main system element of the DAS
- F. Contractor: The prime contractor bidding the project
- G. Passive: DAS components that do not require AC/DC power for operation

1.11 QUALITY ASSURANCE

- A. Source Limitations:
 - 1. Obtain equipment from a single manufacturer.
 - 2. Contractor must have an office within 100 miles of the project site.
 - 3. Contractor or systems integration partner shall provide a cost to have the following major components spared at the Owner's site:
 - a. BDA for used frequency
 - b. Fiber Optic Master Unit
 - c. Fiber Optic Remote Units
- 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. The work specified in this Section is acknowledged to require special skills mastered by education, experience, or both. Bidders for work described in this Section shall be or shall subcontract with established DAS/RF communications contractors. The contractor shall have direct access to all tools and test equipment required to complete the work prior to submitting a bid.
- D. Requirements set forth by first-responder code, ordinance, or the PSN AHJ shall supersede the requirements described herein and shall be met in their entirety. It is the Contractor's responsibility to ensure that the DAS complies with local code, ordinances or requirements established by the PSN AHJ.

E. PSN Approval

1. Contractor shall be responsible for facilitating the AHJ approval(s) per the requirements of the code or ordinance.

1.12 WARRANTY

A. Manufacturer Warranty:

1. Splitters, Couplers and Coverage Antennas: 2-years from date of system acceptance.
2. Coaxial Cable and Connectors: 2-years from date of system acceptance.
3. Fiber-Optic Cable: 20-year limited warranty from date of system acceptance.
4. Active Components: 2-years from date of system installation.

1.13 MAINTENANCE

- A. The Contractor shall provide a maintenance service contract, covering the system for a period of one-year with options up to five years: preventative maintenance, system monitoring, spares, fault mitigation, equipment repair, and response time.

B. Annual Testing

1. As required by Code, the system shall be tested annually beginning one (1) year from the date of final acceptance testing. The contractor or systems integrator shall provide a price for an additional service contract to include the required annual testing as described in part 3 below.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ADRF Technologies
2. Solid Technologies
3. Commscope
4. TE Connectivity
5. Axell Wireless

2.2 RISER HEAD END

- A. 800 MHz Bi-directional Amplifier (BDA)

1. BDA: The BDA shall be channelized and use digital filtering to mitigate interference and accommodate multiple services for PSNs.
2. Characteristics:

- a. Operating Temperature Range: -33 °C to +50 °C
3. Filtering: Digital
 - a. Separate Control: Each RF amplifier shall be capable of adjusting and controlling power levels for each WSP when multiple WSPs share a single amplifier.
 - b. FCC Part 90.219 Type Classification: Class A channelized narrowband for LMR/SMR/ ESMR frequency bands
4. Alarming:
 - a. Shall support both SNMP and SMS using wireless modem
 - b. Shall provide dry contact connection to Fire Alarm Control Panel
5. Mounting Options: Shall support rack or wall mounting
6. Frequency Bands Supported:, 806 - 869 MHz LMR/SMR/ESMR
7. Compliance:
 - a. NFPA: The BDA shall comply with 2012 NFPA-72, chapter 24 requirements for supervision and monitoring.
 - b. FCC: Shall be FCC type certified.
 - c. All equipment shall be UL[®] Listed.

B. FIBER-OPTIC MASTER UNIT:

1. When building size dictates an Active fiber DAS, the Fiber-Optic Master Unit shall convert radio over coax to Radio-Over-Fiber (RoF) for distribution to Fiber-Optic Remote Units.
2. Characteristics
 - a. Transmission Media: Single-mode fiber at 1310 nm
 - b. Operating Temperature Range: +5 °C to +40 °C
 - c. Impedence: 50 Ohm
3. Chassis:
 - a. Modular design capable of supporting up to 32 Remote Units
 - b. Shall support redundant power supplies
 - c. Shall have the capability to remotely power the Remote Units via composite fiber-optic cable
4. Automatic Gain Control (AGC): Shall provide AGC for optical loss compensation
5. Optical Budget: Shall support ≤ 3 dB optical budget (~3 km or 2 miles)
6. Remote Supervision:
 - a. Provide line item pricing to equip the system with remote monitoring capability.
 - b. Remote capacity shall support TCP/IP protocol, SNMPv2, FTP, HTTP, Telnet, and be fully compatible with general purpose SNMP managers
 - c. Remote access shall be available via Point-to-Point Protocol (PPP), over circuit-switched/packet data and wired/wireless modems

- d. Each Active device shall be manageable via a Web GUI
- 7. Frequency Bands Supported: 806 - 869 MHz LMR/SMR/ESMR

C. DONOR ANTENNA

- 1. Public Safety
 - a. 746-986 MHz Yagi Antenna
 - b. Electrical Specifications

Gain	11 dB or greater
VSWR	<1.7 : 1
Polarization	Vertical
Maximum Input Power	100 Watts
Electrical Downtilt	0 °
Front-back Ratio	>16 dB
Connectors	N-Female
Lightning Protection Direct	Ground
Rated Wind Speed	100 mph
Max. Dimensions of Antenna	2.2" x 10" x 36"

D. SURGE ARRESTOR

- 1. DC Blocked Protector
- 2. Flange mounted, dc block, single transmitter coaxial lightning protection for 125MHz to 1GHz with N female connectors
- 3. Mount Type: Flange Mount
- 4. Standards: CE Compliant, RoHS Compliant
- 5. Frequency Range: 125MHz to 1GHz
- 6. Protected Side Connector N Female
- 7. Surge Side Connector: N Female
- 8. Turn On Voltage: 600Vdc \pm 20 %
- 9. VSWR: \leq 1.1:1 Over Frequency Range
- 10. Insertion Loss: \leq 0.1 dB Over Frequency Range
- 11. RF Power: 125 to 220 MHz @ 375 W, 220 to 700 MHz @ 125 W, 700 to 1000 MHz @ 50 W

- E. Omni-Directional Coverage - Omni-Directional Coverage antennas shall feature a multi band design, accommodating multiple frequency bands in a single small antenna.

Pattern Type:	Omnidirectional
Frequency Ranges:	698-960 and 1710-2700 MHz
Gain:	1.9dBd (4dBi) (similar at 2100MHz and 450 MHz)
VSWR:	1.2:1-1.8:1
Polarization:	Multi-Polarized
Impedance:	50 ohms nominal
Diameter:	7.5 in
Height:	7 in
Weight:	1 lb
Connector:	N-Female (others available)
Warranty:	1 Year Limited
Construction:	UV Stabilized ABS
Ground Plane:	Built In
Overall Dimensions	3 in x 3 in x 3 in
Color	Black or White
Pigtail Included	Yes
Pigtail Length	18 in
Application	In Building
Mounting Style	3/4 in stud Mount
Mounting Hardware	Optional L-Bracket Available
H. Beamwidth (deg.)	360

2.3 DONOR ANTENNA CABLING

A. Construction Materials:

1. Jacket Material: Non-Halogenated, fire retardant polyolefin
2. Outer conductor material: Corrugate copper
3. Dielectric Material: Foam PE
4. Flexibility: Standard
5. Inner Conductor Material: Copper
6. Jacket Color: Black

B. Dimensions

1. Nominal Size: (.5 inch)

C. Electrical Characteristics

1. Cable Impedance: 50 ohm \pm 1 ohm
2. Capacitance: 22.0pF/ft
3. Operating Band: 1 – 5000 MHz

D. Mechanical Specifications

1. Fire Retardancy Test Method: UL 1666/ CATVR/ CMR
2. Smoke Test Method: IEC 61034
3. Toxicity Index Test Method: IEC 60754-1/ -2

2.4 DIRECTIONAL COUPLERS

Electrical Specifications	
Operating Frequency Band	698 – 2700 MHz
3rd Order IMD	-140 dBc (relative to carrier)
3rd Order IMD Test Method	Two +43 dBm carriers
Average Power, maximum	200 W
Coupling Tolerance	±1.0 dB
Impedance	50 ohm
Insertion Loss at Frequency Band	0.3 dB @ 698–2700 MHz
Isolation at Frequency Band	20 dB @ 698–2700 MHz
Peak Power, maximum	1 kW
Reflected Power, maximum	200 W
Return Loss, minimum	19.0 dB
VSWR	1.25:1

PART 3 - EXECUTION

3.1 INSTALLATION

- A. The contractor and/ or Systems Integrator shall design, install, commission and test the DAS in accordance with the manufacturer's instructions and recommendations.
- B. Locate equipment, antennas and splitters at locations shown on the contract drawings.
- C. Extend cabling from the EOS enclosures to the splitters in a neat and orderly manner per the routing indicated on the contract drawings. Support cabling in compliance with NEC chapter 8 requirements and manufacturers recommendations.
- D. Maintain a 6" minimum distance from the DAS cabling and other cabling for parallel runs. Do not install coaxial cabling open in any areas where the cabling will be subject to physical damage.
- E. Install antennas as per the mounting details shown in the drawings.

3.2 EQUIPMENT MOUNTING

- A. Install wall mounted EOS Enclosures in equipment spaces as indicated on plans in accordance with manufacturers instructions and seismic requirements.
- B. Install EOS Headend equipment rack in equipment space indicated on the drawings. Fasten to the floor per manufacturers instructions and provide seismic bracing if required in compliance with local codes.
- C. Install donor antennas per details shown on the contract documents.

3.3 COORDINATION WITH OTHER TRADES

- A. Field coordinate the installation of the EOS headend equipment and remotes to ensure that each location is provided with the following:
 - 1. a 120V, 20A circuit for UPS equipment served from the lifesafety generator system.
 - 2. (2) strands of single mode fiber from the head end location to each remote location terminated in AC APC connectors. Coordinate fiber install with low voltage contractor.
 - 3. Grounding per *NEC*[®] and ANSI/TIA/607-C.
 - 4. Coordinate Alarm and Monitoring points with the Fire Alarm contractor.

3.4 EXAMINATION

- A. The contractor must examine areas and conditions under which DAS components are to be installed and notify the owner's representative, in writing of those conditions which are, in the Contractor's opinion, potentially detrimental to proper completion of the work. The Contractor shall not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the owner.
- B. Examine pathway elements intended for cable, check raceways, cable trays and other elements for compliance with space allocations, installations tolerances, hazards to cable installation, and other conditions affecting installation. Proceed with installation only after unsatisfactory conditions have been corrected.
 - 1. Specific items of examination shall include, but shall not necessarily be limited to, the following:
 - a. Locations for all new DAS antennas, cable and splitter equipment.
 - b. The Contractor shall examine all rooms designated to house DAS equipment to ensure adequate space, power, and environment conditions to support installation.

3.5 TESTING

- A. Acceptance testing shall be performed confirming the requirements have been met.

- B. The contractor shall complete the acceptance testing as prescribed in the approved Acceptance Test Plan (ATP) submittal.
- C. Testing Procedure (PSN):
 - 1. Test Location
 - a. Each floor of the building shall be divided into a grid of 20 approximately equal test areas.
 - b. Downlink received signal level measurements shall be recorded in the coverage area using actual RSSI signal from site. Measurements shall be collected using a spectrum analyzer and a dipole antenna.
 - c. Failure of a maximum of two nonadjacent test areas shall not result in failure of the test.
 - d. In the event that three of the test area fail the test, in order to be more statistically accurate, the floor shall be divided into 40 equal equal test areas. Failure of a maximum of four non adjacent test areas shall not result in failure of the test. If the system fails the 40-area test, the system shall be altered to meet the 95% coverage.
 - e. A test location in the center of each test area shall be selected for the test. Once the location has been selected, the location shall represent the entire test area.
 - 2. Equipment Requirements
 - a. Test equipment shall be allowed to stabilize in test environment prior to calibration for a minimum of thirty minutes. Any change in temperature can void the calibration.
 - b. Signal generator must be connected to the Head end downlink (TX) interface via tested and approved coaxial cabling and connectors.
 - c. Signal generator transmits frequency (MHz) and Power (dBm) must be preapproved by project engineer prior to testing. The control channel from the base station can be used as a signal source as well.
 - d. Verify that all remote units for the area under test are ON.
 - e. Test frequency and power must be recorded corresponding to the date and time of each site walk measurement.
 - f. Spectrum analyzer with unity gain (0dB, frequency specific) dipole receive antenna must be preapproved by the project engineer.
 - g. Site walk screen shots shall be saved with frequency span +/- 20 MHz relative to the center/measured frequency.
 - 3. Documentation
 - a. Exact location of measurement must be marked on the grid print.
 - b. Screen shots must be taken in all designated grid spaces. If more than one reading is saved per grid zone, saved results shall be distinguished from one another using Grid##"A", Grid## "B" etc.
 - c. Results of testing are reported to project engineer for analysis and reporting.

D. Proof of Performance and Testing Methodology:

1. Test requirements specified in this document shall be successfully completed prior to issuance of a Certificate of Occupancy and yearly thereafter. Also testing with a successful result shall occur whenever a design change is made to the system, which changes the technical performance or coverage of the system. All tests shall be coordinated 10 days in advance with the AHJ. Results of the test shall be reported in writing to the AHJ.

E. Technical Training

1. The Contractor shall be responsible for organizing a structured demonstration of acceptance tests to ensure organized and efficient testing.
2. The Contractor shall provide written notice to the owner's representative at least thirty (30) calendar days in advance of the initiation of final system acceptance testing. Included in the advance notice shall be three (3) copies of the approved test plans and procedures to ensure acceptance test monitoring personnel are familiar with the tests, procedures and the expected results.
3. It is the responsibility of the Contractor to notify the owner's representative at appropriate times to permit visual inspections of all DAS components. No Installation work shall be covered until a visual inspection has been completed.
4. Provide the owner's representative with the opportunity to witness all testing. On reasonable request and with ten (10) working days' notice, the Contractor shall demonstrate that the test procedure competently identifies the parameter being demonstrated or the fault condition being tested.
5. The Contractor shall provide a Certificate of Compliance signed by a responsible company representative after completion of the site installation. This document shall certify that each element of the installed system and wiring complies with the requirements of the Contract Documents and the certification shall be included with the final acceptance report.
6. The Contractor shall provide training for elements of the DAS. Such training shall include management, operational and maintenance levels and shall be provided to individuals (maximum of 3) to be designated by the owner's representative.
7. Training shall be conducted by qualified personnel fully conversant on the equipment, materials, software, and over all operation of the installed elements. Training shall be based upon as much hands-on training as is possible. The Contractor shall provide all necessary training aids and materials, which shall include written handouts.
8. All training shall be completed prior to Final Acceptance.

3.6 TRAINING

- A. Retain the Systems Integrator to instruct the District Personnel on the proper operation of the system including alarms.
 1. Provide time for two (2), one hour training session.

END OF SECTION 275319

SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. IDC: Insulation displacement connector.
- C. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- D. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- E. RCDD: Registered Communications Distribution Designer

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Installation data for cables as specified in TIA 569-D.
 - 2. For coaxial cable, include the following installation data for each type used:
 - a. Nominal OD.
 - b. Minimum bending radius.
 - c. Maximum pulling tension.
- B. Shop Drawings:
 - 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 to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.
- C. Field quality-control reports.

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 the direct supervision of RCDD.
 2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.
- B. Testing Agency Qualifications: Certified by BICSI.
 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 1. Test each pair of paired cables for open and short circuits.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

- D. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

2.2 RS-232 CABLE

- A. Plenum-Type, TIA 232-F

1. Three, 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.

2.3 RS-485 CABLE

- A. Plenum-Rated Cable: NFPA 70, Type CMP.

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. Flame Resistance: NFPA 262, Flame Test.

2.4 CONTROL-VOLTAGE CABLE

- A. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.

1. One pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with NFPA 262.

2.5 CONTROL-CIRCUIT CONDUCTORS

- A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.
- B. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in pathway.

- C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF in pathway, complying with UL 83.

2.6 FIRE ALARM WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Comtran Corporation.
 - 2. Genesis Cable Products; Honeywell International, Inc.
 - 3. Rockbestos-Suprenant Cable Corp.
 - 4. West Penn Wire; a brand of Belden Inc.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum, in pathway.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum, in pathway.

2.7 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation.
 - 2. HellermannTyton.
 - 3. Kroy LLC.
 - 4. PANDUIT CORP.
- B. 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 GROUNDING

- A. Comply with TIA-607-B.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

- A. Cable Trays: Comply with NEMA VE 2 and TIA-569-B.

- B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
- C. Comply with requirements in Division 26 for installation of conduits and wireways.
- D. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- E. Pathway Installation in Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Install cable trays to route cables if conduits cannot be located in these positions.
 - 3. Secure conduits to backboard when entering room from overhead.
 - 4. Extend conduits 3 inches (75 mm) above finished floor.
 - 5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- F. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Division 26 for installation of supports for pathways, conductors and cables.

3.3 WIRING METHOD

- A. Install wiring in metal pathways and wireways.
 - 1. Minimum conduit size shall be 3/4 inch (21 mm). Control and data-transmission wiring shall not share conduits with other building wiring systems.
- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring on Racks and within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 2. Cable ties shall not be excessively tightened such that the transmission characteristics of the cable are altered.
 - 3. Install lacing bars and distribution spools.
 - 4. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.
 - 5. Install conductors parallel with or at right angles to sides and back of enclosure.
 - 6. Connect conductors associated with intrusion system that are terminated, spliced, or interrupted in any enclosure onto terminal blocks.
 - 7. Mark each terminal according to system's wiring diagrams.

8. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.4 GENERAL REQUIREMENTS FOR INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1, NFPA 70, and TIA-568-C.1.
- B. Comply with BICSI Information Technology Systems Installation Methods Manual for installation of equipment in communications equipment spaces.
- C. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- D. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
- E. Install balanced twisted-pair, optical-fiber, and coaxial cables and connecting materials after spaces are complete and dry, and HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- F. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels. Leave a minimum of 6 inches (150 mm) of slack at outlet terminations and coil loosely into box after termination on outlet fitting.
- G. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- H. Maintain minimum cable bending radius during installation and termination of cables.
- I. 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.
- J. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
- K. Pulling Cable: Monitor cable pull tensions. Do not exceed manufacturer's rated cable-pulling tension.
- L. Riser Cable: Riser cable support intervals shall be in accordance with manufacturer's recommendations.
- M. Open-Cable Installation:
 1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.

2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart. Cable supports shall be fastened to structural members or floor slabs in accordance with Section 270529 "Hangers and Supports for Communications Systems."
3. Cable shall not be run in contact with pipes, ducts, or other potentially damaging items. Cables shall not be run through structural members or use structural members, pipes, ducts, or equipment as a support.

N. Separation from EMI Sources:

1. Comply with BICSI Telecommunications Distribution Methods Manual and TIA-569-D recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communication cables or cables in nonmetallic pathways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (600 mm).
3. Separation between communication cables in grounded metallic pathways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between cables in grounded metallic pathways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or hp and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Cables and Fluorescent Luminaires: A minimum of 5 inches (127 mm).

3.5 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.

- B. Wiring Method: Install wiring in metal pathway according to division 27.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated pathway system. This system shall not be used for any other wire or cable.
- C. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- E. Color Coding: Color code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and another 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.
- F. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.

3.6 POWER AND CONTROL-CIRCUIT CONDUCTORS

- A. 120-V Power Wiring: Install according to division 26 unless otherwise indicated.
- B. Minimum Conductor Sizes:
 - 1. Class 1 remote-control and signal circuits, No. 14 AWG.
 - 2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
 - 3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.7 FIRESTOPPING

- A. Comply with TIA-569-D.
- B. Comply with BICSI Information Technology Systems Installation Methods Manual.

3.8 GROUNDING

- A. For communication wiring, comply with TIA-607-B and with BICSI Telecommunications Distribution Methods Manual "Bonding and Grounding (Earthing)" chapter.
- B. For low-voltage wiring and cabling, comply with requirements in division 27.

3.9 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Division 26.

3.10 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Visually inspect balanced twisted-pair and optical-fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color coding for pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 3. Test balanced twisted-pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
 - a. Test instruments shall comply with or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- B. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

END OF SECTION 280513

SECTION 280526 - GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Comply with requirements in section 270526 "Grounding and Bonding for Communications Systems" and provide grounding and bonding provisions for electronic safety and security systems.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 280526

SECTION 280528 - PATHWAYS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Comply with requirements in section 270528 "Pathways for Communications Systems" to provide similar provisions for electronic safety and security systems cabling pathways.
- B. Comply with requirements in Division 27 for Cable Trays for Communications Systems to install electronic safety and security systems cabling in cable trays where required.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 280528

SECTION 280544 - SLEEVES AND SLEEVE SEALS FOR ELECTRONIC SAFETY AND SECURITY
PATHWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling" to provide similar provisions for electronic safety and security systems pathways cabling.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 280544

SECTION 281300 - ACCESS CONTROL

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 DEFINITIONS

- A. SMS: Security Management System.
- B. API: Application Programming Interface.
- C. LDAP: Lightweight Directory Access Protocol.
- D. NTSC: National Television Standards Committee.
- E. PAL: Phase Alternating Line. PAL is the color video standard used in Europe and many other countries.
- F. CCTV: Closed-circuit television.
- G. CPU: Central processing unit.
- H. Credential: Data assigned to an entity and used to identify that entity.
- I. dpi: Dots per inch.
- J. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- K. GFI: Ground fault interrupter.
- L. 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.
- M. I/O: Input/Output.
- N. LAN: Local area network.
- O. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A

communications loop. Where this term is presented with an initial capital letter, this definition applies.

- P. PC: Personal computer. Applies to the central station, workstations, and file servers.
- Q. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.
- R. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.
- S. RAS: Remote access services.
- T. RF: Radio frequency.
- U. ROM: Read-only memory. ROM data are maintained through losses of power.
- V. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
- W. 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.
- X. UPS: Uninterruptible power supply.
- Y. USB: Universal serial bus.
- Z. WAN: Wide area network.
- AA. WAV: The digital audio format used in Microsoft Windows.
- BB. WMP: Windows media player.
- CC. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- DD. Windows: Operating system by Microsoft Corporation.
- EE. Workstation: A PC with software that is configured for specific, limited security-system functions.
- FF. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.3 REFERENCE STANDARDS

- A. Where more than one (1) reference standard, code, or regulation applies, the more stringent one shall govern.
- B. Electronic Industries Alliance (EIA):

1. EIA RS-170 - Standard for Composite Video Signals.
- C. Federal Communications Commission (FCC).
 1. FCC Part 15 - Unlicensed RF Devices EME/EMC.
 2. FCC Part 68 - Requirements for Connecting to the U.S. Phone Network.
- D. Institute of Electrical and Electronics Engineers, Inc. (IEEE).
- E. International Organization for Standardization (ISO).
- F. International Radio Consultive Committee (CCIR).
- G. Microsoft® Open Database Connectivity (ODBC) Interface.
- H. National Fire Protection Association (NFPA):
 1. NFPA 70 - National Electrical Code.
- I. National Institute of Standards and Technology (NIST):
 1. NIST SP800-116
 2. Federal Information Processing Standards Publication (FIP PUBS 197) - Specification for the Advanced Encryption Standard (AES).
- J. National Television Standards Committee (NTSC):
 1. Color Camera Broadcast Standard.
- K. Underwriters Laboratories Inc. (UL):
 1. UL 294 - Standard for Access Control System Units.
 2. UL 1076 - Standard for Proprietary Burglar Alarm Units and Systems.
 3. UL 1981 - Standard for Central-Station Automation Systems.
 4. UL 1610 Central Station Automation System Software.

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. Manufacturer's technical data for all material and equipment at the system and sub system level to be provided as part of the SMS.
 2. A system description including analysis and calculations used in sizing equipment required by the SMS. The description shall show how the equipment will operate as a system to meet the performance requirements of the SMS. The following information shall be supplied as a minimum:

- a. Server(s) processor(s), disk space and memory size.
- b. Description of site equipment and its configuration.
- c. Network bandwidth, latency and reliability requirements.
- d. Backup or archive system size and configuration.
- e. Startup operations.
- f. System expansion capability and method of implementation.
- g. System power requirements and UPS sizing.
- h. Device or component environmental requirements (cooling and or heating parameters).
- i. A description of the operating system and application software.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Indicate all system device locations on architectural floor plans. No other system(s) shall be included on these plans.
2. Include full schematic wiring information on these drawings for all devices. Wiring information shall include cable type, conductor routings, quantities, and connection details at device.
3. Include a complete SMS one-line, block diagram.
4. Include a statement of the system sequence of operation.

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 017823 "Operation and Maintenance Data," include the following:

1. Provide 3 sets electronic format manuals including operating instructions, maintenance recommendations and parts list including wiring and connection diagrams modified to reflect as-built conditions.
2. Manuals: Deliver final copies of the manuals within 30 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the Contractor responsible for the installation and maintenance of the system and the factory representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. The manuals shall consist of the following:
 - a. Functional Design Manual: Identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. Include a description of hardware and software functions, interfaces, and requirements.

- b. Hardware Manual: Describe equipment furnished including:
 - 1) General description and specifications.
 - 2) Installation and check out procedures.
 - 3) Equipment layout and electrical schematics to the component level.
 - 4) System layout drawings and schematics.
 - 5) Alignment and calibration procedures.
 - 6) Manufacturer's repair parts list indicating sources of supply.
- c. Software Manuals: Describe the functions of software and include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
 - 1) Definition of terms and functions.
 - 2) System use and application software.
 - 3) Initialization, startup, and exit.
 - 4) Reports generation.
 - 5) Details on forms customization and field parameters.
- 3. As-Built Drawings: During system installation, the Contractor shall maintain a separate hard copy set of drawings, elementary diagrams, and wiring diagrams of the SMS to be used for record drawings. This set shall be accurately kept up to date by the Contractor with all changes and additions to the SMS. Copies of the final as-built drawings shall be provided to the end user in DXF format.

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. Alarm Printer Black/Red Ribbons: Package of 12.
 - 2. Laser Printers: Three toner cassettes and one replacement drum unit.
 - 3. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
 - 4. 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. Manufacturer Qualifications:
 - 1. SMS manufacturer shall be an established organization with referenced and documented experience delivering and maintaining SMS of equal or higher sophistication and complexity as compared to the system detailed in this specification.
 - 2. SMS manufacturer shall employ at a minimum the following methods for quality assurance of component and assembly devices:

- a. Perform visual inspection of devices to verify assembly according to defined procedures. Perform end of line operational tests to ensure product functionality has been correctly configured.
- b. Perform individual functionality and system level regression testing to ensure compliance with product specifications. Perform single and multiple unit system tests to mimic end-user installation configurations. Utilize automated hardware and software testing to evaluate system performance under published operational loads and compare to published system capabilities.

B. Bidder Qualifications:

1. At the time of the bid, the bidder shall have satisfactorily completed projects of a similar size, scope and complexity as the system detailed in this specification. The bidder shall furnish written proof of experience from three (3) references and proof of current accreditation or certification by the manufacturer for required training for sales or installation or service of the SMS and associated devices.
2. The bidder shall also be a factory authorized local service organization that shall carry a complete stock of parts and provide maintenance for the SMS and related systems under this contract. Local shall be defined as an area in a (75) mile radius of installed location.
3. RFI Communications & Security Systems, 19717 62nd Avenue South, Suite F103, Kent, WA 98032-1153, Phone: (253) 981-6100 is a pre-approved and preferred installer for security management system.

C. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

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

E. Comply with NFPA 70, "National Electrical Code."

F. E. Comply with SIA DC-01 and SIA DC-03.

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 (10 and 30 deg C), 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.
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 (16 to 30 deg C) 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 (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
 3. Indoor, Uncontrolled Environment: NEMA 250, Type 3R 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 (minus 18 to plus 50 deg C) 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 (minus 34 to plus 50 deg C) 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 (137 km/h).

1.11 WARRANTY

- A. SMS, Third-party, and Access Control and Digital Video Warranty:
1. SMS manufacturer warrants that the product disc and hardware key shall be free from defects in material and workmanship and that SMS software product will function in substantial accordance to SMS manufacturer's specifications. Any defective dongle will be replaced at no charge provided that the system is currently on a supported version of SMS software. Dongles for non-supported versions will be replaced for a cost.
 2. All SMS manufacturer branded access control hardware (LNL-500 through LNL-8000) are provided with a three (3) year warranty from the date of shipment to the Reseller. SMS manufacturer warrants that such products will be free from defects in material and workmanship and that they will operate in general accordance with their product specifications. The parts will be repaired or replaced at the manufacturer's option. Reseller shall follow SMS manufacturer's procedures for RMA with these products. SMS manufacturer provides repair or replacement of SMS manufacturer branded components for up to five years from the product discontinuance date.
 3. Transfer SMS third-party device warranties from the manufacturer to the Contractor, which may then transfer third-party warranties to the Owner. Specific third-party warranty details, terms and conditions, remedies and procedures, are either expressly stated on, or packaged with, or accompany such products. The warranty period may vary from product to product. These products include but are not limited to devices that are directly interconnected to the SMS field hardware or computers and are purchased directly from the SMS manufacturer. Examples may include but not be limited to: credential printers, reader heads, biometric devices, computers, etc.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Lenel Systems International, Inc.: LENEL ONGUARD ES Series access control system. No substitutions.

2.2 SECURITY MANAGEMENT SYSTEM (SMS) DESCRIPTION

- A. The Security Management System (SMS) outlined in this section is the key central component for managing physical security and the bridge between physical and logical security for a project. The system shall provide a variety of integral functions including: regulation of access and egress; provision of identification credentials; monitor, track and interface alarms and; view, record and store digital surveillance video linked to SMS events.
- B. The SMS shall utilize a single seamlessly integrated relational database for all functions utilizing a fully multi-tasking multi-threading Microsoft Windows 7 SP1 or 8/8.1 or Server 2008 R2 SP1 or Server 2012 or Server 2012 R2 Operating System. The SMS shall be written so that all system modules (access control, alarm monitoring, ID or credential management, visitor management and digital video management) are developed and built from a unified single 64-bit source code set. Separate source code bases for individual modules of the SMS are not acceptable.
- C. Upgrades or expansion of the SMS to a larger size system in scale shall not require installation of a different and/or new SMS application or require the administrator or operator to learn a different and or new interface from the previous version.
- D. The SMS shall be written using Unicode format. Unicode enables a single software product to be targeted across multiple platforms and languages without re-engineering and allows for data to be transported through different systems without corruption. The SMS graphical user interface shall be available in the following single-byte languages: Arabic (ARA), Croatian (HRV), Czech (CSY), Dutch (NLD), English (ENU), Finnish (FIN), French (FRA), German (DEU), Hebrew (HEB), Italian (ITA), Polish (PLK), Portuguese Brazil (PTB), Russian (RUS), Spanish (ESP), Swedish (SVE), and Turkish. The SMS graphical user interface shall be available in the following double-byte languages: Chinese Simplified (CHS), Chinese Traditional (CHT), Korean (KOR), and Japanese (JPN). Language Accessory Add-ons shall require a special language-specific license bit in order for the Language Pack to be used.
- E. The SMS shall be UL 1076 Listed.
- F. The SMS shall be UL 1981 Listed.
- G. The SMS shall be UL 1610 Listed.
- H. The SMS shall have FIPS 140-2 certification.
- I. The SMS shall have FIPS 197 certification.

- J. The SMS shall have NIST SP800-116 support.
- K. The SMS shall only require a single license key to be present on the database server for the SMS to operate. The license key shall either be a physical device or a software license key. The SMS shall allow the SMS USER the ability to activate, return, or repair the software license key. The software license shall only be used on a physical computer or in a VMware virtual environment. License keys shall not be required at the client workstations. The license key on the database server shall determine the number of client workstations that shall be able to connect to the SMS as well as all SMS functionality. An alarm shall be generated in the SMS's Alarm Monitoring application as the license expiration date approaches.
- L. The License Administration login and password shall be encrypted when they are passed to the License Server. The hash shall not be the same data even with the same logon credentials on different systems. This is a requirement for U.S. government DIACAP certification.
- M. The SMS shall support concurrent licensing with respect to client licenses. CUSTOMER shall purchase a fixed number of client workstation licenses (or connections) that shall be programmed into the database server license file. The SMS shall be installed on any number of client workstations in the CUSTOMER facility. Then, any of the client workstations that have the SMS software installed shall have the ability to connect to the database server as long as the maximum number of concurrent connections purchased has not been reached. Connections shall be licensed on a per module basis. This shall provide CUSTOMER with great flexibility in system design and layout.
- N. The SMS shall provide support for single sign-on capability. Single sign-on shall allow System Administrators or System Operators to authenticate into SMS applications using their Windows domain account.
 - 1. Single sign-on shall support the following scenarios:
 - a. Allow System Administrators or System Operators to interactively run SMS applications without having to enter a username or password. This shall make administration of the SMS easier since maintenance of separate SMS usernames and passwords is not required.
 - b. Allow SMS API scripts to authenticate. These scripts shall be run using a Windows account allowing a seamless and secure way to authenticate the account and restricting the script to those actions that the user is permitted to perform.
- O. The SMS shall be able to seamlessly interface with and monitor intelligent system controllers, reader interface modules, I/O panels, alarm panels, alarm panel receivers, biometric devices, personal protection devices, intercom systems, fire alarm panels (secondary monitoring only), building management systems and digital video recorders approved for use by the SMS manufacturer.
- P. The SMS shall be able to communicate with intelligent system controllers via RS-485, RS-232, TCP/IP (IPv4 and IPv6) or Ethernet, and dialup via modem.
- Q. Tasks shall be accessible from any compatible client workstation on the network utilizing one (1) or all of the following:

1. Traditional client-server architecture.
 2. N-tier architecture where the SMS supports the expansion of the system architecture and allows for user deployment based upon their system architectural needs. The SMS shall allow for, but not require, the separation of the database, application server, Web server, and client interface. The system shall require that all connections to the database be performed through a trusted link from the client or internet browser interface.
 3. Centralized distribution (publishing) of applications using Windows Terminal Server and Citrix® on Windows, UNIX, Linux or Apple Macintosh based systems through any compatible internet browser application and/or by means of a mobile computing platform using a wearable computer, Tablet PC, or PDA device.
- R. Utilize an open architecture where all data must reside on a single database and must be accessible in real time to SMS workstation or Web-based client connected to the network. The system shall be configurable to support all of the following databases: Microsoft SQL Server 2008 SP2 and SP3, Microsoft SQL Server 2008 R2 SP1 and SP2, Microsoft SQL Server 2012 SP1 and Express, Microsoft SQL Server 2014 and Express, Oracle Server 11g R1 and R2, and Oracle Server 12c R1. Oracle data may reside on Windows or UNIX platforms.
- S. Transparent data encryption (TDE) shall be supported. TDE shall perform real-time I/O encryption and decryption of the database and database log files. (Standard SMS log files shall not be encrypted, and TDE shall not provide encryption across communication channels.)
- T. The system architecture shall support Microsoft Windows Clustering, Hot Standby, Fault Tolerant Servers and Fault Tolerant Hot Standby Servers.
- U. The SMS shall be able to connect to and interface bi-directionally with external data sources utilizing all of the following methods:
1. ASCII with support for XML formatted text exchange of data activated both manually and automatically.
 2. ASCII with support for XML formatted text exchange of data using a direct table interface activated both manually and automatically.
 3. Real-time exchange of data via Active Directory or LDAP utilizing an API (Application Programming Interface) written by the SMS manufacturer. The live exchange of data shall expose SMS events and transactions to other data sources in real-time and allow for receipt of data into the SMS where this data may be acted upon and trigger linked events in the SMS in real-time.
- V. The SMS shall support:
1. Lenel OnGuard® ES Series: 64 access control readers, unlimited number of inputs or outputs, 5 client workstations.

2.3 COMPONENTS

- A. SMS Software Capabilities: Support an unlimited number of card readers, input points, video cameras, intrusion detection points, and relay outputs. The SMS database server shall support an unlimited number of cardholders, visitors, and assets limited only by the available memory on the ISC. The database server shall also support an unlimited number of system events and

System Operator transactions in the history file limited only by available hard disk space. Client Workstations shall be limited only by the limitations of the operating system server software. The SMS functions are categorized into nineteen primary "system modules" which shall include:

1. Access Control:
 - a. One of the SMS's primary purposes shall be to provide access control. The SMS shall be able to make access granted or denied decisions, define access levels, and set timezones and holidays. An input or output linkage feature shall allow linking of monitor zone points to output control points within Intelligent System Controllers (ISCs). The SMS shall support features such as area control (two man control, hard, soft, and timed anti-passback), database segmentation, and timezone or holiday overrides.
2. Alarm Monitoring:
 - a. The main Alarm Monitoring window shall provide information about the time and location of the alarm, along with its priority. The main Alarm Monitoring window must be able to sort pending and/or insert new alarms based on any of the following attributes: priority, date or time, alarm description, Intelligent System Controller, Card Reader, Input Control Module, asset name, or cardholder. Date or time sorts must be System Operator selectable to be either ascending or descending and must have the option of displaying the seconds of the minute in which the alarm arrived into the SMS. All columns of information in the main Alarm Monitoring window shall be able to be arranged in any order by the System Operator.
 - b. The SMS must allow unique emergency instructions to be specified for each type of alarm. It shall also allow for the automatic sending of alphanumeric pages or e-mail messages upon alarm arrival. It shall allow for the sending of alarms to a Central Station. A real-time graphical system status tree on the screen shall indicate if card readers, alarm panels, digital video recorders, video cameras, intrusion detection panels, or Intelligent System Controllers are secured, unsecured, in alarm, or offline. Output control operations must be available to lock, unlock or pulse control points as a standard feature. An automatic cardholder call-up feature shall allow the quick search and display of images in the database. A System Operator journal shall be available to log important daily events. A trace function shall be available for System Operators to locate and track activity on specific cardholders, assets, video cameras, or card readers. An image comparison feature must be provided for use in conjunction with a CCTV interface. All alarms and hardware icons MUST have the ability to control the associated hardware via right-mouse clicks.
 - c. The SMS must provide the option to be used as a UL 1981 Classified Central Station Automation System. This option must be classified by Underwriters Laboratories for use as a Commercial Burglar Central Station Automation System, to allow the monitoring station where it is used to be made compliant with the UL 1981 standard and listed by UL. This classification shall apply to alarm panels monitored through a connected, UL approved Central Station Alarm Receiver.
 - d. The SMS shall allow the SMS user to specify the limit for the number of alarms that can be loaded to the Alarm Monitoring application. The limit shall be per

Alarm Monitoring application and shared between multiple views (Main, Trace, Pending) within the same application. One single alarm that appears in multiple views shall only be counted once against the total limit. For example, if 100 identical alarms appear in both Main and Trace views, only 100 (not 200) are counted against the total limit.

- 1) This limit must be applied to the Main Alarm Monitor view. Automatic clearing of alarms must only apply to the Main Alarm Monitor view, and occur if selected.
 - 2) This limit must be applied to the Pending Alarms view. Pending Alarm windows must never be automatically cleared.
 - 3) This limit should be applied to Trace monitors, but only affect the stopping of live alarms into the client. Trace Monitors must never be automatically cleared.
 - e. Alarm Monitoring shall provide a mechanism for automatic cleanup of previously loaded alarms when the limit is reached. This method shall be FIFO (First In, First Out) based and remove 50% (if possible) of the alarms from the monitor to restore receiving events. Configuration of this method shall be available within Alarm Monitoring using typical methods.
3. Credential Management:
- a. The SMS shall include a seamlessly integrated credential management module. The credential management functionality must allow the enrollment of cardholders into the database, capturing of images, biometric data, and signatures, as well as the import or export of employee data. This functionality shall also allow the System Operator to assign and/or modify the access rights of a cardholder.
 - b. The SMS shall include a seamlessly integrated state-of-the-art, 64-bit, credential creation and production system. This shall allow for the creation of different badge types based on a database field, the linking of that field to a badge type to automate the process of credential production, and the use of security colors, chromakey, and ghosting, to allow officers to quickly identify personnel access authority.
 - c. The SMS shall have the ability to crop and rotate an image automatically based on the orientation of the eyes found in the image. This shall include photographs captured from digital cameras, live cameras, scanned images and imported images.
 - d. SMS Credential Printers: The SMS credential management module shall be compatible with printers and printer or encoders from Zebra, Magicard, and NiSCA that support Microsoft Certified drivers for Windows 7 SP1, Windows 8/8.1, Windows Server 2008 R2 SP1, Windows Server 2012, and Windows Server 2012 R2. The SMS shall support double-sided full color printing on printers that have that capability. The SMS shall also support edge-to-edge printing on printers that have that capability. The SMS shall support high-speed printing on printers that have that capability. The SMS shall also support holographic overlays on printers that have that capability.
4. Badge Layout Creation:
- a. The SMS shall provide a Badge Layout Creation and Editing Module to allow for the creation of custom badge designs to be created by the CUSTOMER. The SMS

shall support credit card, government, and custom credential sizes in either a landscape or portrait format and shall support double sided and edge-to-edge printing.

5. Digital Video Management:

- a. The SMS shall include a seamlessly integrated digital video management module. It shall support real-time linkage of digital video clips to their associated alarms as well as those from linked devices in the SMS database; Access Control hardware for example. This linkage shall happen automatically as defined by the configuration.
- b. System Administrators shall define parameters for video segment creation by specifying pre-alarm and post-alarm durations. The system shall automatically associate alarms from linked hardware with the linked camera's pre- and post-alarm durations.
- c. System Administrators shall configure video segments by specifying pre- and post-alarm time marks, then link those defined video segments to specific alarms. Each camera shall be configured to have its own unique set of pre- and post-alarm time marks, video quality settings, and failover recorder. The SMS shall allow for the central administration, monitoring, and archiving of digital video and the associated cameras. The SMS shall have the ability to launch video on alarm.
- d. The SMS shall support the ability to define video behavior by alarm type. The SMS will dynamically apply the behavior in real-time as alarms come in.
- e. The SMS shall support Digital Video Recorders from multiple manufacturers. The SMS shall also support IP-based digital cameras and digital video encoders or servers from multiple manufacturers for advanced video surveillance. The SMS shall support H.264, MJPEG, MPEG4 simple profile encoding standards and frame rates to include both PAL and NTSC respectively at maximum of 25/30 frames per second (FPS). In addition, the SMS shall support a network-based digital video recorder.
- f. The SMS shall integrate with a video management system (VMS) such as Prism, for event-driven monitoring via event proxy. The integration of the SMS and VMS shall provide a collaborative and inter-operable environment for configuration, event/alarm monitoring, and system administration.

6. Door Intercom Entry System:

- a. The door intercom entry system shall provide audio and visual communications from the door to desk top mounted 7" touch screen base station located at the receptions desk at both east and west main admin office entrances with door release functions through the access control system. Provide programming and connections from the relay ports to the access control system for a fully functional operating door intercom entry system.
- b. Provide equal to Aiphone Model No, JK-DV (camera door station) with JM-4MED (Base Station).

7. Integration with Intercommunications and program system:

- a. The SMS system shall include a seamless integration with school intercommunication system. The building lock down function shall be initiated by

entering a passcode on any phone/intercom device located in the building. Provide all components for a complete system.

8. Visitor Management:

- a. The SMS shall include a visitor management module. The visitor management module shall be an application utilizing technology that allows a CUSTOMER to track and display access control system activity.
- b. The visitor management module shall keep track of staff signing in and out and shall display the information on display monitors located in the east and west main entry vestibules.
- c. The visitor management software shall be installed on two remote workstation PCs located at the east and west main admin office/reception. The PCs will be owner furnished. The software shall have the capability to be run in the background without making it a dedicated and allowing the PC to be used for normal use.
- d. Provide all accessories required for a complete turnkey system including display monitors with mounting brackets, cabling and any signal amplifiers/media converters required for remote PC application.

9. System Administration:

- a. System Administrative tasks such as defining client workstation and System Operator permissions set-up, access groups, timezones, reports, maps, etc. shall be provided from any client workstation on the network. Initial setup of the cardholder screen layout shall occur on the database server. The SMS shall support the use of strong passwords.

10. Server Redundancy:

- a. The SMS shall support a fault tolerant server and redundant database architecture. The SMS shall also allow for a server clustering architecture. The SMS shall allow for normal operations to occur in the event that the Database Server fails. In the event of a server failure, the switch over to a backup server from a primary server shall be automatic and not impede the operation of the SMS.

B. System Software: Central-server, 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 Microsoft Windows.
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 Microsoft Windows.
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 Microsoft Windows-based TCP/IP with a capacity of connecting up to 99 workstations. System shall be portable across multiple communication platforms without changing system software.
- D. Network(s) connecting PCs 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. Direct-connected, RS-232 cable from the COM port of the central station to the first controller, then RS-485 cable to interconnect the remaining controllers at that Location.

2.4 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 32,000 separate Locations using a single PC with combinations of direct-connect, dial-up, 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. Data Capacity:
 - 1. 130 different card-reader formats.
 - 2. 999 comments.
 - 3. 48 graphic file types for importing maps.
- E. Location Capacity:
 - 1. 64 reader-controlled doors.
 - 2. 50,000 total-access credentials.
 - 3. 2048 supervised alarm inputs.
 - 4. 2048 programmable outputs.
 - 5. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.
- F. 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.
- G. Central server 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.
- H. 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.
- I. System Response to Alarms:
1. Field device network shall provide a system end-to-end response time of one second(s) or less for every device connected to the system.
 2. Alarms shall be annunciated at the central station within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the central station.
 3. Alarm and status changes shall be displayed within 100 ms after receipt of data by the central station.
 4. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within five seconds of alarm receipt at the security console.
- J. 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.
- K. 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.

- L. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
- M. Door Hardware Interface:
 - 1. Comply with requirements in Section 087100 "Door Hardware" 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.

2.5 APPLICATION SOFTWARE

- A. System Software: Based on 64-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. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, 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 PC. 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 PC. This operation shall be at the controller.
 - 7. Messages from PC 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 PC-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 PC 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.

C. 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.

D. 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.

E. PC-to-Controller Communications:

1. Central-station or workstation communications shall use the following:
 - a. Direct connection using serial ports of the PC.
 - 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 (NIV) shall have an option to set the poll-frequency and message-response time-out settings.
6. PC-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.

F. Direct Serial or TCP/IP PC-to-Controller Communications:

1. Communication software on the PC shall supervise the PC-to-controller communications link.
2. Loss of communications to any controller shall result in an alarm at all PCs running the communication software.
3. When communications are restored, all buffered events shall automatically upload to the PC, and any database changes shall be automatically sent to the controller.

G. 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.

H. Database Downloads:

1. All data transmissions from PCs 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 PC. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.

I. 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.
- J. 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 32 passwords 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.
- K. 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 four times a day through time-zone programming.
 - 2) Arm or disarm each monitored input up to four times a day through time-zone programming.
 - 3) Enable or disable readers or keypads up to two times a day through time-zone programming.
 - 4) Enable or disable cards or codes up to four 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.

L. 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, zone and sensor.
 - 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. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
 - 6. 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.
- M. 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 of alarm, location of alarm, and secondary alarm messages.
 - 2. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
 - 3. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.
 - 4. 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.
 - 5. Each workstation shall display the total pending alarms and total unresolved alarms.

6. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
 7. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
 8. 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.
 9. 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.
 10. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
 11. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
 12. 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.
 13. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.
 14. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.
- N. 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.
- O. 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.
- P. 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. Activity and Alarm On-Line Printing: Activity printers for use at workstations; prints all events, or alarms only.
13. 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 PC.
 - 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.
14. 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.
15. 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.
16. The reports of system database shall allow options so that every data field may be printed.
17. 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.

Q. 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 PC (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.

R. 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.

S. Time and Attendance:

1. Time and attendance reporting shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
2. Shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
3. System software setup shall allow designation of selected access-control readers as time and attendance hardware to gather the clock-in and clock-out times of the users at these readers.
 - a. Reports shall show in and out times for each day, total time in for each day, and a total time in for period specified by the user.

- b. Allow the operator to view and print the reports, or save the reports to a file.
 - c. Alphabetically sort reports on the person's last name, by Location or location group. Include all credential holders or optionally select individual credential holders for the report.
- T. 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.
- U. 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, this shall include biometric data. 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.

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 PC 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. Feature in first subparagraph below helps speed data entry.
 8. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
 9. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
 10. 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.
 11. 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.
 12. 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. Key control and tracking shall be an integrated function of cardholder data.
1. Provide the ability to store information about which conventional metal keys are issued and to whom, along with key construction information.
 2. Reports shall be designed to list everyone who possesses a specified key.
- H. Facility Codes: System shall accommodate up to 2048 facility codes per Location, with the option of allowing facility codes to work at all doors or only at particular doors.
- I. 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.
- J. 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. The SMS shall be capable of assigning Access Groups with a maximum of 32 Access Levels per Access Group.
 3. Each Access Group shall be assignable to an alphanumeric name using up to 64 characters.
 4. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
 5. Allow sorting of history reports and code list printouts by group name.
- K. Time Zones:
1. The SMS shall be capable of creating and storing up to 255 timezones. Each timezone shall have a minimum of six (6) intervals. Each interval shall be assignable to any day of the week.
 2. Each timezone shall be assignable to an alphanumeric name of up to 64 characters. Timezones shall be applied to access levels, card reader modes, alarm inputs, alarm

outputs, and alarm masking and logging functions. Timezones shall be allowed to belong to any or all access levels so that the timezone only has to be defined once.

L. Holidays:

1. The SMS shall provide a minimum of 255 Holiday assignments using an embedded calendar. Holidays shall be assigned an alphanumeric name using up to 64 characters and shall be grouped into eight (8) types of holidays, and shall be assignable to individual timezones. Access rights, card reader modes, and alarm masking schedules must be able to be altered when the current date is designated a Holiday.
2. Dates for Daylight Saving Time changes shall be definable and shall take effect automatically.
3. The SMS shall support Holiday Ranges that allow a single holiday to span across multiple calendar days.
4. Holidays shall be able to be configured to repeat yearly.

M. Access Levels:

1. Capable of defining a minimum of 32,000 access levels with a minimum of 128 access levels per cardholder per database segment. Access levels shall consist of a combination of card readers and timezones.
2. Each access level shall be assignable to an alphanumeric name using up to 64 characters.
3. Card readers shall have the ability to be assigned to any or all access levels defined in the SMS. Individual card readers shall be capable of having a distinct timezone assigned to it.
4. Allow an 'Allow User Commands' option to be assigned on a per access level basis where keypad readers are in use.
5. Allow a 'First Card Unlock' option to be assigned on a per access level basis.

N. 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.

O. Code Tracing:

1. System shall perform code tracing selectable by cardholder and by reader.
2. Any code may be designated as a "traced code" with no limit to how many codes can be traced.
3. Any reader may be designated as a "trace reader" with no limit to which or how many readers can be used for code tracing.
4. When a traced code is used at a trace reader, the access-granted message that usually appears on the monitor window of the central station shall be highlighted with a different color than regular messages. A short singular beep shall occur at the same time the highlighted message is displayed on the window.
5. The traced cardholder image (if image exists) shall appear on workstations when used at a trace reader.

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.
- 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 CENTRAL-SERVER HARDWARE

- A. Central-Server Computer: Central – Server Computer shall be furnished by the owner and will have following minimum hardware requirements:
 1. Dell Precision TS3610 Mid-Tower.
 2. Intel® Xenon® E5-1603, Quad Core, 2.8 GHz Turbo, 10 MB.
 3. 635 W power supply.
 4. 8 GB (4 x 2 GB) 1600 MHz, DDR3 Non-ECC
 5. 8X DVD+/-RW
 6. 500 GB 3.5 inch Serial ATA (7.200 Rpm) Hard Drive
 7. 1 GB NVIDIA® Quadro® K600 (1 DP & 1 DVI-I) (1 DP-DVI & 1 DVI-VGA adapter)
 8. Windows 7 Professional 64-bit (includes Windows 8 Professional license)
 9. RJ45 Ethernet port
 10. Internal chassis speakers
 11. (6) USB 2.0 ports, (4) USB 3.0 ports
 12. (1) serial port
 13. USB keyboard/mouse
 14. Report Printer:
 - a. Connected to the central station and designated workstations.
 - b. Laser printer with minimum resolution of 600 dpi.
 - c. RAM: 2 MB, minimum.
 - d. Printing Speed: Minimum 12 pages per minute.

- e. Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.

2.9 STANDARD WORKSTATION HARDWARE

- A. Workstation Computer: Workstation Computer shall be furnished by the owner and will have following minimum hardware requirements:

- 1. Dell OptiPlex 3020 Small Form Factor.
- 2. Intel Core i3-4130 Processor (Dual Core, 3 MB cache, 3.40 GHz)
- 3. 4 GB – non-ECC – 1600 MHz – DDR3 [1 DIMM]
- 4. 8x Slimline DVD +/- RW
- 5. 500 GB 3.5 inch Serial ATA (7,200 Rpm) hard drive
- 6. 1 GB AMD RADEON™ HD 8490 –Dual MON (1 DP & 1 DVI)
- 7. Windows 7 Professional 64-bit
- 8. RJ45 Ethernet port
- 9. Internal chassis speakers
- 10. (6) USB 2.0 ports
- 11. (2) USB 3.0 ports
- 12. USB keyboard/mouse
- 13. Printer:
 - a. Connected to the central station and designated workstations.
 - b. Laser printer with minimum resolution of 600 dpi.
 - c. RAM: 2 MB, minimum.
 - d. Printing Speed: Minimum 12 pages per minute.
 - e. Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.

2.10 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, provide controllers by Lenel Systems International Inc. Part No. LNL-2220 for intelligent dual reader controller and LNL-1320 series 2 for entry control controller.
- 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, with dc line supervision on each of its alarm inputs.

- 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.

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, biometric personnel identity-verification devices, 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 20 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 50,000 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: 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.
 - b. 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.

2.11 CARD READERS, CREDENTIAL CARDS, AND KEYPADS

- A. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
- B. 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.
- C. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.
 2. Indoors, uncontrolled environment.
 3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
- D. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
- E. Touch-Plate and Proximity Readers:
1. 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.
 2. The card reader shall read proximity cards in a range from direct contact to at least 6 inches (150 mm) from the reader.
- F. Communication Protocol: Compatible with local processor.
- G. Touch-Plate and Contactless Card Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
- H. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
- I. Card Size and Dimensional Stability: Credential cards shall be 2-1/8 by 3-3/8 inches (54 by 86 mm). The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
- J. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
- K. Card Construction:
1. Core and laminate or monolithic construction.
 2. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
 3. Incorporate holographic images or phosphorous ink as a security enhancement.
 4. Furnish equipment for on-site assembly and lamination of credential cards.

2.12 DOOR AND GATE HARDWARE INTERFACE

- A. Exit Alarm: Operation of a monitored door shall generate an alarm. Request to Exit devices are integrated with door locks at some locations and are specified in Section 087100 "Door Hardware." Provide motion sensor type Request to Exit devices at all other locations as indicated on the drawings.

- B. 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 087100 "Door Hardware."

2.13 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.

2.14 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, biometric personnel identity-verification devices, 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.

2.15 CABLES

- A. A. General Cable Requirements: Comply with requirements in Section 280513 "Conductors and Cables for Electronic Safety and Security" and as recommended by system manufacturer for integration requirement.
- A. Plenum-Type, TIA 232-F Cables:
 1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; plastic jacket.
 2. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 3. NFPA 70, Type CMP.
 4. Flame Resistance: NFPA 262 flame test.
- B. Plenum-Type, TIA 485-A Cables:
 1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.

2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

C. 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.

D. Paired, Plenum-Type, Lock Cables:

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

E. Paired, Plenum-Type, Input Cables:

1. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, aluminum-foil/polyester-tape shield (foil side out), with No. 22 AWG drain wire, 100 percent shield coverage, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

F. Paired, Plenum-Type, AC Transformer Cables:

1. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

G. LAN Cabling:

1. Comply with requirements in Section 280513 "Conductors and Cables for Electronic Safety and Security."
2. NFPA 262.

2.16 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 PCs, 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/EIA 606-A, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents 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. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
 - 5. Assign action message names and compose messages.
 - 6. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
 - 7. Prepare and install alarm graphic maps.
 - 8. Develop user-defined fields.
 - 9. Develop screen layout formats.
 - 10. Propose setups for guard tours and key control.
 - 11. Discuss badge layout options; design badges.
 - 12. Complete system diagnostics and operation verification.
 - 13. Prepare a specific plan for system testing, startup, and demonstration.
 - 14. Develop acceptance test concept and, on approval, develop specifics of the test.
 - 15. 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 Project planning documents and review, adjust, and prepare final setup documents. Use final documents 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 280513 "Conductors and Cables for Electronic Safety and Security."
- C. 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.
- D. Install LAN cables using techniques, practices, and methods that are consistent with Category 5E rating of components and fiber-optic rating of components, and that ensure Category 6 and fiber-optic performance of completed and linked signal paths, end to end.
- E. 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.
- F. 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-B, "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. (15 m).
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 ft. (1220 m).
- 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. (75 m), and install No. 20 AWG wire if maximum distance is 500 ft. (150 m).
 - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
 - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

- F. Install minimum No. 18 AWG cable from controller to electrically powered locks. Do not exceed 250 ft. (75 m).
- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 ft. (8 m).

3.5 GROUNDING

- A. Comply with Section 260526 "Grounding and Bonding for Electrical 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 INSTALLATION

- A. Install card readers, keypads, and request to exit devices.
- B. Integrate electronic security system with the following systems and equipment:
 - 1. Electronic door hardware.
 - 2. Intercommunications and program systems.
 - 3. Intrusion detection system.
 - 4. Video surveillance.
 - 5. Door Video Intercom system.

3.7 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 260553 "Identification for Electrical Systems" and with TIA/EIA 606-A.
- B. Using computer software 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 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.

3.8 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.

3.9 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 Class 2, bidirectional, Category 5 tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA 568-B.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA 568-B.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.

3.10 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.

3.11 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.

3.12 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 017900 "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. Corporate management.

END OF SECTION 281300

SECTION 281600 – INTRUSION DETECTION SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. PIR: Passive infrared.
- B. RFI: Radio-frequency interference.
- C. UPS: Uninterruptible power supply.
- D. Control Unit: System component that monitors inputs and controls outputs through various circuits.
- E. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
- F. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
- G. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
- H. Standard Intruder: A person who weighs 100 lb (45 kg) or less and whose height is 60 inches (1525 mm) or less; dressed in a long-sleeved shirt, slacks, and shoes.
- I. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
- J. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
- K. Zone. A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

1.3 ACTION SUBMITTALS

- A. Product Data: Components for sensing, detecting, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
 - 1. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
 - 2. UPS: Sizing calculations.
 - 3. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building.
 - 4. Master Control-Unit Console Layout: Show required artwork and device identification.
 - 5. Device Address List: Coordinate with final system programming.
 - 6. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
 - 7. Details of surge-protection devices and their installation.
 - 8. Sensor detection patterns and adjustment ranges.
- C. Design Data: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Product Warranty: Sample of special warranty.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Data for each type of product, including features and operating sequences, both automatic and manual.
 - 2. Master control-unit hardware and software 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. Intrusion Detection Devices: Furnish quantity equal to five percent of the number of units of each type installed, but no fewer than one of each type.
2. Fuses: Three of each kind and size.
3. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
4. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. An employer of workers, at least one of whom is a Certified Alarm Technician, Level 1.
2. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
3. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
4. Installation Supervision: Installation shall be under the direct supervision of Technician, who shall be present at all times when Work of this Section is performed at Project site.
5. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.

1. At least one of whom is a Certified Systems Integrator.

C. Testing Agency Qualifications: Certified by BICSI.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.8 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Altitude: Sea level to 4000 feet (1220 m).
2. Master Control Unit: Rated for continuous operation in an ambient of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
3. Interior, Controlled Environment: System components, except master control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambients of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing.
4. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Comply with

UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h).

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.

- 1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURER

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. BOSCH, no substitutions.

2.2 RACEWAYS

- A. Provide metallic raceways cables installed in wall, above inaccessible ceilings, exposed or where subject to physical damage. Raceway fill shall not exceed 40 percent.
- B. Only devices and underground raceways have been shown on the drawings. The Contractor shall provide a complete design-build raceway system.

2.3 BOXES

- A. Provide four 11/16" square by 2 1/8" deep box with single-gang plaster ring.
- B. Provide 3/4" raceway from each device to an accessible ceiling location. Provide plastic bushings on both ends of the raceway.

2.4 CABLING

- A. Provide all cabling per Division 27.
- B. Interior: Provide the following to each DMP XR550 Station: (1) CAT 6a cable.

2.5 FUNCTIONAL DESCRIPTION OF SYSTEM

- A. Description: Hard-wired, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.
- B. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
 - 1. Alarm Signal: Display at master control unit and actuate audible and visual alarm devices.
 - 2. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or control-unit failure.
 - 3. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or control unit.
- C. System Control: Master control unit shall directly monitor intrusion detection units and connecting wiring.
- D. System Control: Master control unit shall directly monitor intrusion detection devices and connecting wiring in a multiplexed distributed control system or as part of a network.
- E. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.
- F. Operator Commands:
 - 1. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
 - 2. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
 - 3. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
 - 4. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
 - 5. Protected Zone Test: Initiate operational test of a specific protected zone.
 - 6. System Test: Initiate system-wide operational test.
 - 7. Print reports.
- G. Timed Control at Master Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
- H. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
 - 1. Switch selected lights.
 - 2. Shift elevator control to a different mode.
 - 3. Open a signal path between certain intercommunication stations.

4. Shift sound system to "listening mode" and open a signal path to certain system speakers.
 5. Switch signal to selected monitor from CCTV camera in vicinity of sensor signaling an alarm.
-
- I. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
 - J. Response Time: Two seconds between actuation of any alarm and its indication at master control unit.
 - K. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at master control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
 - L. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
 - M. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.

2.6 SYSTEM COMPONENT 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. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.
- C. FM Global Compliance: FM-Approved and -labeled intrusion detection devices and equipment.
- D. Comply with NFPA 70.
- E. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit shall be selected and configured with accessories for full compatibility with the following equipment:
 1. Door hardware specified in Division 01.

2. Door hardware specified in Division 01.
 3. Access control system specified in Division 28.
 4. Fire alarm system specified in Division 28.
 5. Video surveillance system specified in Division 28.
- F. 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 Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits."
 2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Listed and labeled by a qualified testing agency for compliance with NFPA 731.
- G. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
- H. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V rms injected into power supply lines at 10 to 10,000 MHz.
- I. Tamper Protection: Tamper switches on detection devices, control units, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Master control-unit alarm display shall identify tamper alarms and indicate locations.
- J. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master control unit.
- K. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master control unit as an alarm signal.
- L. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master control unit.
- M. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master control unit for calibration, sensitivity, and alarm condition.

2.7 ENCLOSURES

- A. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
- B. Interior Electronics: NEMA 250, Type 12.

- C. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.8 SECURE AND ACCESS DEVICES

- A. BOSCH Model D1260 or most current model, no substitutions.
- B. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.

2.9 DOOR CONTACTS

- A. BOSCH Model ISN-CTC75 or current model, no substitutions.

2.10 MICROWAVE-PIR DUAL-TECHNOLOGY SENSORS

- A. BOSCH Model ISC-PPR1-W16, no substitutions.
- B. Description: Single unit combining a sensor that detects changes in microwave signals and a PIR sensor that detects changes in ambient level of infrared emissions caused by standard-intruder movement within detection pattern.
- C. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.
- D. Device Performance: An alarm is transmitted when either sensor detects a standard intruder within a period of three to eight seconds from when the other sensor detects a standard intruder.
 - 1. Minimum Detection Pattern: A room 20 by 30 feet (6 by 9 m).
 - 2. PIR Sensor Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across two adjacent segments of detector's field of view.
 - 3. Microwave Sensor Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
 - 4. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
 - 5. Remote Test: When initiated by master control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

2.11 MASTER CONTROL UNIT

- A. BOSCH Model 9412G Series or most current model, no substitutions

- B. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
1. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 2. Include a real-time clock for time annotation of events on the event recorder and printer.
 3. Addressable initiation devices that communicate device identity and status.
- C. Construction: Freestanding equipment rack, modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.
- D. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: LCD, two line(s) of 40 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
 3. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
 4. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
 5. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
 - a. Acknowledge alarm.
 - b. Silence alarm.
 - c. System reset.
 - d. LED test.
 6. Timing Unit: Solid state, programmable, 365 days.
 7. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
 8. Alarm Indication: Audible signal sounds and an LED lights at master control unit identifying the addressable detector originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.

- E. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
- F. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
- G. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than 1 inch (25 mm) high. Identify, with permanent labels, individual components and modules within cabinets.
- H. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
- I. Printout of Events: On receipt of 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 same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

2.12 AUDIBLE AND VISUAL ALARM DEVICES

- A. Bell: 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from master control unit.
 - 1. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
- B. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.
 - 1. Designed for use in industrial areas and in high-noise, severe-weather marine environments.
- C. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from master control unit.
 - 1. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
- D. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
 - 1. Light Output: 115 cd, minimum.

2. Flash Rate: 60 per minute.

2.13 SECURITY FASTENERS

- A. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
- B. Socket Flat Countersunk Head Fasteners:
 1. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 2. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
- C. Socket Button Head Fasteners:
 1. Heat-treated alloy steel, ASTM F 835 (ASTM F 835M).
 2. Stainless steel, ASTM F 879 (ASTM F 879M), Group 1 CW.
- D. Socket Head Cap Fasteners:
 1. Heat-treated alloy steel, ASTM A 574 (ASTM A 574M).
 2. Stainless steel, ASTM F 837 (ASTM F 837M), Group 1 CW.
- E. Protective Coatings for Heat-Treated Alloy Steel:
 1. Zinc chromate, ASTM F 1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
 2. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
- B. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
- D. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.

1. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
 2. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
- E. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SYSTEM INTEGRATION

- A. Integrate intrusion detection system with the following systems and equipment:

1. Electronic door hardware.
2. Network lighting controls.
3. Access control.
4. Fire-alarm system.
5. Video surveillance.

3.3 SYSTEM INSTALLATION

- A. Comply with UL 681 and NFPA 731.
- B. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
- C. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
1. Comply with requirements for seismic-restraint devices specified in Division 27.
- D. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of the building.
 2. Connect new equipment to existing monitoring equipment at the Supervising Station.
 3. Expand, modify, and supplement existing monitoring equipment as necessary to extend existing monitoring functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- E. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project.

3.4 WIRING INSTALLATION

- A. Wiring Method: Install wiring in metal raceways according to Division 27. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be 1/2 inch (13 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- D. Wires and Cables:
 - 1. Conductors: Size as recommended in writing by system manufacturer unless otherwise indicated.
 - 2. 120-V Power Wiring: Install according to Division 26 unless otherwise indicated.
 - 3. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 27.
 - 4. Data and Television Signal Transmission Cables: Install according to Division 27.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- F. Install power supplies and other auxiliary components for detection devices at control units unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
- G. Identify components with engraved, laminated-plastic or metal nameplate for master control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 27.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with identification requirements in Division 27.
- B. Install instructions frame in a location visible from master control unit.

3.6 GROUNDING

- A. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.

- B. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- C. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
- D. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 27.

3.7 FIELD QUALITY CONTROL

- A. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
 - 1. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
- B. Perform tests and inspections.
- C. Tests and Inspections: Comply with provisions in NFPA 731, Ch. 9, "Testing and Inspections."
 - 1. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 - 2. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
- D. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
- E. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.

3.8 DEMONSTRATION

- A. Train Owner's maintenance personnel, on site, to adjust, operate, and maintain the intrusion detection system. Comply with documentation provisions in NFPA 731, Ch. 4, "Documentation and User Training."

END OF SECTION 281600

SECTION 282300 - VIDEO SURVEILLANCE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes a video surveillance system consisting of cameras, data transmission wiring, and an IP Video System.
- B. Video surveillance system shall be integrated with monitoring and control system specified in Section 281600 "Intrusion Detection," and Section 281300 "Access Control," which specifies systems integration.

1.3 DEFINITIONS

- A. AGC: Automatic gain control.
- B. CCD: Charge-coupled device.
- C. FTP: File transfer protocol.
- D. IP: Internet protocol.
- E. LAN: Local area network.
- F. MPEG: Moving picture experts group.
- G. NTSC: National Television System Committee.
- H. PC: Personal computer.
- I. PTZ: Pan-tilt-zoom.
- J. RAID: Redundant array of independent disks.
- K. TCP: Transmission control protocol - connects hosts on the Internet.
- L. UPS: Uninterruptible power supply.
- M. WAN: Wide area network.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For video surveillance. 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. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
 - 3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
 - 4. Wiring Diagrams: For power, signal, and control wiring.
- C. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

1.6 INFORMATIONAL SUBMITTALS

- A. Seismic Qualification Certificates: For video surveillance, cameras, camera-supporting equipment, 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.
- B. Field quality-control reports.
- C. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, and control-station components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - 1. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.8 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 NECA 1.
- C. Comply with NFPA 70.
- D. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

1.9 PROJECT CONDITIONS

- A. Environmental Conditions: 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 temperatures of 60 to 85 deg F (16 to 29 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
 - 2. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
 - 3. Interior, Uncontrolled Environment: System components installed in non-air-conditioned interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F (minus 18 to plus 50 deg C dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 3R enclosures.
 - 4. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h). Use NEMA 250, Type 3R enclosures.
 - 5. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.10 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM REQUIREMENTS

- A. The cameras shall be IP based network type providing a 100Base-TX network interface for live streaming to a standard Web browser.
- B. Network cameras shall support standard IT protocols.
- C. The network camera shall support industry standard Power over Ethernet (PoE), IEEE 802.3af to supply power to the camera over the network.
- D. The network camera shall offer a video output port providing an NTSC/PAL analog video output signal for adjusting the field of view and when focusing the camera.
- E. Appliance based recording with network management capabilities.
- F. Appliance based recorder to be located at local site of interest.
- G. Software client must have ability for local viewing of camera and viewing from the District at any given location within the District network base.

2.2 REINFORCED DOME IP CAMERAS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Arecont Vision; MegaDome® 2 IP Megapixel Cameras or comparable product by one of the following:
1. Sony.
2. Axis Communications.
- B. Exterior Locations: MegaDome ® 2 AV10255PMIR-SH: 10 Megapixel H.264 IP camera with 4.7-9mm Remote Zoom, Remote Focus and P-Iris Lens, SDHC Card and IR LEDs
1. 10-Megapixel/1080p dual mode network camera.
2. Fully H.264 (MPEG-4, Part 10) compliant, provides full 3648 x 2752 megapixel resolution at full video frame rates of 7 frames per second (fps) at 10-megapixel and 29fps in 1080p binned mode.

3. An all-in-one solution with integrated 10-megapixel day/night camera, remote focus, remote zoom, auto-iris lens (AM model) or P-Iris (PM model), 4.7-9mm (AM model), 4-10mm (PM model) or 12-22mm (PMT model) lens options, SDHC card (-S model), scaling.
 4. IP66 water/dust ingress rating and vandal resistant dome enclosure IK-10 rating.
 5. Electrical Power
 - a. General purpose opto-coupled input and output
 - b. Power over Ethernet (PoE): PoE 802.3af
 - c. Auxiliary Power 12-48V DC, 24VAC
 - d. Power consumption: PoE – Class 3
 6. Built-in IR illuminator (-IR Model)
 - a. 24 pcs 850nm LEDs / 50ft (15m) IR distance (max) / 40° IR angle (PMIR Model)
 - b. 24 pcs 850nm LEDs / 120ft (36m) IR distance (max) / 30° IR angle (PMTIR Model)
 - c. Total PoE Solution (No external power requirement)
 7. Built-in Heater Option
 - a. Power Output: 2.28 W Max
 - b. Switch: On: 4C° (32.9 °F), Off: 6.5 °C (43.7 °F)
 - c. Total PoE Solution: No external power requirement
 8. Lens included.
- C. Interior Locations: MegaDome ® 2 AV3256PMIR-S: 3 Megapixel WDR H.264 day/night IP camera with 3-9mm Remote Zoom, Remote Focus and P-Iris Lens, SDHC Card and IR LEDs
1. 3-Megapixel/1080p dual mode network camera.
 2. Fully H.264 (MPEG-4, Part 10) compliant, provides full 2048 x 1536 megapixel resolution at full video frame rates of 21 frames per second (fps).
 3. An all-in-one solution with integrated 3 megapixel WDR (wide dynamic range) camera, remote focus, remote zoom, P-iris lens, 3-9mm (PM model) or 8-22mm (PMT model) lens options.
 4. IP66 water/dust ingress rating and vandal resistant dome enclosure IK-10 rating; the AV3256PM camera line provides an all-in-one solution with integrated 3.4-10.5mm lens.
 5. Electrical Power
 - a. General purpose opto-coupled input and output
 - b. Power over Ethernet (PoE): PoE 802.3af
 - c. Auxiliary Power 12-48V DC, 24VAC
 - d. Power consumption: PoE – Class 3
 6. Built-in IR illuminator (-IR Model)
 - a. 24 pcs 850nm LEDs / 50ft (15m) IR distance (max) / 40° IR angle (PMIR Model)
 - b. 24 pcs 850nm LEDs / 120ft (36m) IR distance (max) / 30° IR angle (PMTIR Model)

c. Total PoE Solution (No external power requirement)

7. Lens included.

2.3 POWER SUPPLIES

A. All cameras and housing blower heaters shall be powered over Ethernet PoE.

2.4 CAMERA-SUPPORTING EQUIPMENT

A. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Arecont Vision.
2. Sony.
3. Axis Communications.

B. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.

C. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.

D. Protective Housings for Fixed and Movable Cameras: Steel or 6061 T6 aluminum enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and mounting and installing arrangement of camera to be housed.

1. Camera Viewing Window: Polycarbonate window, aligned with camera lens.
2. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.
3. Built-in, thermostat-activated heater and blower units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded.
4. Sun shield shall not interfere with normal airflow around the housing.
5. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
6. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.
7. Enclosure Rating: NEMA 250, Type 3R.

2.5 IP VIDEO SURVEILLANCE APPLIANCE

A. Appliance based IP Video Surveillance System ("System") shall allow the display of live, record and playback of digital video streams from multiple video surveillance IP cameras, simultaneously, on the System's operator console and/or on other display and control platforms including clients, virtual matrix display, PDA and Cell phone.

- B. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
 - 1. Milestone Husky Model M50, 16TB hard drive.
- C. Appliance will have the following features:
 - 1. (2) NIC cards for communication; for local camera VLAN and for District LAN connectivity.
 - 2. Hot swap hard drives (all –OS and recording drives).
 - 3. Appliance OS must allow for standard windows RDP (Remote Desktop Protocol) remote management of the OS.
 - 4. Appliance VMS Software must be interactive with active directory for user sign on.
 - 5. Client viewing software must be capable of using active directory for user sign on.
 - 6. 3-year appliance warranty by manufacturer.
- D. Appliance will be sized for the following:
 - 1. 30 days storage.
 - 2. Resolution; 1080p HD
 - 3. Minimum 10 fps recording on motion activity.
 - 4. 1 fps recording continues on all cameras.
 - 5. 5-year support license.

2.6 PoE NETWORK SWITCHES

- A. PoE network switches shall be owner furnished, contractor installed. Contractor shall provide the basic requirements and a count for the total number of network switches required.

2.7 IP VIDEO MANAGEMENT SYSTEM

- A. Basis-of-Design Product: Subject to compliance with requirements, provide Milestone Video Management System customized and pre-loaded for the recording appliance.
- B. Description:
 - 1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
 - 2. System shall have seamless integration of all video surveillance and control functions.
 - 3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
 - 4. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.

5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
6. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
7. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
8. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.
9. System shall be fully compatible and shall provide seamless integration with Lenel OnGuard security management system (Access Control)

2.8 SIGNAL TRANSMISSION COMPONENTS

- A. Cable: Comply with requirements in Section 280513 "Conductors and Cables for Electronic Safety and Security" and Section 271513 "Communications Copper Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN, WAN, and IP network before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 WIRING

- A. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Wiring Method: Install cables in raceways unless otherwise indicated.
 1. Except raceways are not required in accessible indoor ceiling spaces and attics.
 2. Except raceways are not required in hollow gypsum board partitions.
 3. Conceal raceways and wiring except in unfinished spaces.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

- E. For LAN connection and copper communication wiring, comply with Section 271513 "Communications Copper Horizontal Cabling."
- F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

- A. Install cameras and infrared illuminators level and plumb.
- B. Install cameras with 84-inch- (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
- C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
- D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
- E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
- F. Identify system components, wiring, cabling, and terminals according to Section 260553 "Identification for Electrical Systems."
- G. Install and configure video management software on owner furnished base server and any work stations.

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. Tests and Inspections:
 - 1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
 - 2. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
 - a. Prepare equipment list described in "Informational Submittals" Article.
 - b. Verify operation of auto-iris lenses.

- c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
 - d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
 - e. Set and name all preset positions; consult Owner's personnel.
 - f. Set sensitivity of motion detection.
 - g. Connect and verify responses to alarms.
 - h. Verify operation of control-station equipment.
 3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
 4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
- C. Video surveillance system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
1. Check cable connections.
 2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
 3. Adjust all preset positions; consult Owner's personnel.
 4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
 5. Provide a written report of adjustments and recommendations.

3.6 CLEANING

- A. Clean installed items using methods and materials recommended in writing by manufacturer.
- B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.7 DEMONSTRATION

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

END OF SECTION 282300

SECTION 283111 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product, including furnished options and accessories.
 - 1. Include construction details, material descriptions, dimensions, profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, and electrical characteristics.
- B. Shop Drawings: For fire-alarm system.
 - 1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - 2. Include plans, elevations, sections, details, and attachments to other work.
 - 3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
 - 4. Detail assembly and support requirements.
 - 5. Include voltage drop calculations for notification-appliance circuits.
 - 6. Include battery-size calculations.
 - 7. Include input/output matrix.
 - 8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
 - 9. Include performance parameters and installation details for each detector.
 - 10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.
 - a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 - b. Show field wiring required for HVAC unit shutdown on alarm.
 - c. Locate detectors according to manufacturer's written recommendations.
 - d. Show air-sampling detector pipe routing.
12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified, fire-alarm technician; Level III minimum.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following and deliver copies to authorities having jurisdiction:

- a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
- c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
- d. Riser diagram.
- e. Device addresses.
- f. Record copy of site-specific software.
- g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:
 - 1) Equipment tested.
 - 2) Frequency of testing of installed components.
 - 3) Frequency of inspection of installed components.
 - 4) Requirements and recommendations related to results of maintenance.
 - 5) Manufacturer's user training manuals.
- h. Manufacturer's required maintenance related to system warranty requirements.
- i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 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. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
 2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
 3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
 4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than one unit of each type.
 5. Keys and Tools: One extra set for access to locked or tamper-proofed components.
 6. Audible and Visual Notification Appliances: One of each type installed.
 7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.8 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

1.9 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.
- B. Noncoded, UL-certified and FM Global-placarded addressable system, with multiplexed signal transmission and voice/strobe evacuation.
- C. Automatic sensitivity control of certain smoke detectors.
- D. All components provided shall be listed for use with the selected system.
- E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
 - 1. Manual stations.
 - 2. Heat detectors.
 - 3. Smoke detectors.
 - 4. Duct smoke detectors.
 - 5. Automatic sprinkler system water flow.
 - 6. Preaction system.
 - 7. Fire-extinguishing system operation.
 - 8. Fire standpipe system.

9. Dry system pressure flow switch.
- B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances, including voice evacuation notices.
 2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
 3. Transmit an alarm signal to the remote alarm receiving station.
 4. Unlock electric door locks in designated egress paths.
 5. Release fire and smoke doors held open by magnetic door holders.
 6. Activate voice/alarm communication system.
 7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 8. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 9. Activate preaction system.
 10. Recall elevators to primary or alternate recall floors.
 11. Activate elevator power shunt trip.
 12. Activate emergency lighting control.
 13. Activate emergency shutoffs for gas and fuel supplies.
 14. Record events in the system memory.
 15. Record events by the system printer.
 16. Indicate device in alarm on the graphic annunciator.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
 2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.
 3. Elevator shunt-trip supervision.
 4. User disabling of zones or individual devices.
 5. Loss of communication with any panel on the network.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
 4. Loss of primary power at fire-alarm control unit.
 5. Ground or a single break in internal circuits of fire-alarm control unit.
 6. Abnormal ac voltage at fire-alarm control unit.
 7. Break in standby battery circuitry.
 8. Failure of battery charging.
 9. Abnormal position of any switch at fire-alarm control unit or annunciator.
 10. Voice signal amplifier failure.
- E. System Supervisory Signal Actions:
1. Identify specific device initiating the event at fire-alarm control unit and remote annunciators.
 2. Record the event on system printer.

3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system.
5. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

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

1. SIMPLEX 4100 series, no substitutions allowed.

- B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer.
 - c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
 - d. The FACP shall be listed for connection to a central-station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

- C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and

supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, three line(s) of 40 characters, minimum.
2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Pathway Survivability: Level 1.
3. Install no more than 50 addressable devices on each signaling-line circuit.
4. Serial Interfaces:
 - a. One dedicated RS 485 port for central-station operation using point ID DACT.
 - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
 - c. One USB or RS 232 port for PC configuration.
 - d. One RS 232 port for voice evacuation interface.

E. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Record events by the system printer.
4. Sound general alarm if the alarm is verified.
5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification-Appliance Circuit:

1. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:
 - a. Elevator lobby detectors except the lobby detector on the designated floor.
 - b. Smoke detector in elevator machine room.
 - c. Smoke detectors in elevator hoistway.
2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.
3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
 - a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

- H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.
- I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
- J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.
 - 1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
 - a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
 - b. Programmable tone and message sequence selection.
 - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
 - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.
 - 2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
 - 3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
- L. Printout of Events: On receipt of 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 same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
- M. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals and supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
 - 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.

- N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

- O. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 PREACTION SYSTEM

- A. Initiate Presignal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a preaction system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

2.6 MANUAL FIRE-ALARM BOXES

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

1. SIMPLEX. no substitutions allowed

- B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
5. Mounting Faceplate: Factory finished, WHITE.

2.7 SYSTEM SMOKE DETECTORS

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

1. SIMPLEX. no substitutions allowed

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be four-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
 - b. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135 or 155 deg F (57 or 68 deg C).
 - c. Multiple levels of detection sensitivity for each sensor.
 - d. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Mounting Faceplate: Factory finished, WHITE.

D. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.

- d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
- 3. Mounting Faceplate: Factory finished, WHITE.
- E. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
 - 1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
 - 2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
 - 3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
 - 4. Each sensor shall have multiple levels of detection sensitivity.
 - 5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
 - 6. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.8 HEAT DETECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. SIMPLEX. no substitutions allowed
- B. General Requirements for Heat Detectors: Comply with UL 521.
 - 1. Temperature sensors shall test for and communicate the sensitivity range of the device.
- C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
 - 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 3. Mounting Faceplate: Factory finished, WHITE.
- D. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).
 - 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
3. Mounting Faceplate: Factory finished, WHITE.

2.9 NOTIFICATION APPLIANCES

- A. Manufacturers: Subject to compliance with requirements available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. SIMPLEX. no substitutions allowed.
- B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.
 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- C. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
- D. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
- E. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens.
 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall mounted unless otherwise indicated.
 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 4. Flashing shall be in a temporal pattern, synchronized with other units.
 5. Strobe Leads: Factory connected to screw terminals.
 6. Mounting Faceplate: Factory finished, WHITE.
- F. Voice/Tone Notification Appliances:
 1. Comply with UL 1480.
 2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
 3. High-Range Units: Rated 2 to 15 W.
 4. Low-Range Units: Rated 1 to 2 W.
 5. Mounting: Semirecessed.
 6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

G. Exit Marking Audible Notification Appliance:

1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.
2. Provide exit marking audible notification appliances at the entrance to all building exits.
3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.10 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 120-V ac.

B. Material and Finish: Match door hardware.

2.11 GRAPHIC ANNUNCIATOR

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

1. SIMLPEX. no substitutions allowed.

B. Graphic Annunciator Panel: Mounted in an aluminum frame with nonglare, minimum 3/16-inch- (4.76-mm-) thick, clear acrylic cover over graphic representation of the facility. Detector locations shall be represented by red LED lamps. Normal system operation shall be indicated by a lighted, green LED. Trouble and supervisory alarms shall be represented by an amber LED.

1. Comply with UL 864.
2. Operating voltage shall be 24-V dc provided by a local 24-V power supply provided with the annunciator.
3. Include built-in voltage regulation, reverse polarity protection, RS 232/422 serial communications, and a lamp test switch.
4. Semiflush mounted in a NEMA 250, Type 1 cabinet, with key lock and no exposed screws or hinges.
5. Graphic representation of the facility shall be a CAD drawing and each detector shall be represented by an LED in its actual location. CAD drawing shall be at 1/16-inch per foot scale or larger.
6. The LED representing a detector shall flash two times per second while detector is an alarm.

2.12 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
 - 1. Mounting: Flush cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.13 ADDRESSABLE INTERFACE DEVICE

- A. General:
 - 1. Include address-setting means on the module.
 - 2. Store an internal identifying code for control panel use to identify the module type.
 - 3. Listed for controlling HVAC fan motor controllers.
- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.
 - 1. Allow the control panel to switch the relay contacts on command.
 - 2. Have a minimum of two normally open and two normally closed contacts available for field wiring.
- D. Control Module:
 - 1. Operate notification devices.
 - 2. Operate solenoids for use in sprinkler service.

2.14 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.
 - 4. Manual test report function and manual transmission clear indication.
 - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 - 1. Address of the alarm-initiating device.
 - 2. Address of the supervisory signal.
 - 3. Address of the trouble-initiating device.
 - 4. Loss of ac supply.
 - 5. Loss of power.
 - 6. Low battery.
 - 7. Abnormal test signal.
 - 8. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.15 NETWORK COMMUNICATIONS

- A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.
- B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.
- C. Provide integration gateway using BACnet for connection to building automation system.

2.16 DEVICE GUARDS

- A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
 - 1. Factory fabricated and furnished by device manufacturer.
 - 2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
 - 1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
- B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."
 - 1. Devices placed in service before all other trades have completed cleanup shall be replaced.
 - 2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.
- B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Manual Fire-Alarm Boxes:
 - 1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
 - 2. Mount manual fire-alarm box on a background of a contrasting color.
 - 3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.
- D. Smoke- or Heat-Detector Spacing:
 - 1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.

2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.
 3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A or Annex B in NFPA 72.
 5. HVAC: Locate detectors not closer than 60 inches (1520 mm) from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.
- E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
- F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.
1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.
- G. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.
- H. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
- I. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
- J. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.
- K. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.
- L. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- 3.3 PATHWAYS
- A. Pathways shall be installed in EMT.
 - B. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
 - 2. Smoke dampers in air ducts of designated HVAC duct systems.
 - 3. Magnetically held-open doors.
 - 4. Electronically locked doors and access gates.
 - 5. Alarm-initiating connection to elevator recall system and components.
 - 6. Alarm-initiating connection to activate emergency lighting control.
 - 7. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 - 8. Supervisory connections at valve supervisory switches.
 - 9. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
 - 10. Supervisory connections at elevator shunt-trip breaker.
 - 11. Data communication circuits for connection to building management system.
 - 12. Supervisory connections at fire-extinguisher locations.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 and as noted below.
- B. Install framed instructions in a location visible from fire-alarm control unit.
- C. Label devices as follows:
 - 1. Initiating devices:
 - a. (Circuit ID – Device Number) (M## - ##)
 - 2. Notification Devices:
 - a. (Panel ID – NAC Circuit Number – Device Number) (P## - N## - ##)
 - 3. Junction and Pull boxes:
 - a. Legally write on the cover with indelible ink-pen the circuits contained in each box.
 - b. Covers for all boxes containing fire alarm circuits shall be painted red.

3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform the following tests and inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.
- G. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

- H. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 DEMONSTRATION

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

END OF SECTION 283111

SECTION 311000 – SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Stripping and stockpiling rock.
6. Removing above- and below-grade site improvements.
7. Disconnecting, capping or sealing, and removing site utilities.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
1. Section 312000 – Earth Moving
 2. Section 312500 – Erosion and Sediment Control

1.3 DEFINITIONS

- A. Subsoil: Soil beneath the level of subgrade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.
- B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.
- C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.
- D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches in diameter; and free of weeds, roots, toxic materials, or other nonsoil materials.
- E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

- F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated on Drawings.
- G. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.4 PREINSTALLATION MEETINGS

- A. Pre-installation Conference: Conduct conference at Project Site.

1.5 MATERIAL OWNERSHIP

- A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.6 INFORMATIONAL SUBMITTALS

- A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
 - 1. Use sufficiently detailed photographs or video recordings.
 - 2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.
- B. Topsoil stripping and stockpiling program.
- C. Rock stockpiling program.
- D. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.7 QUALITY ASSURANCE

- A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.
- B. Rock Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

1.8 FIELD 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 trafficways if required by Owner or 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. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on site.
- D. Utility Locator Service: Notify One Call for area where Project is located before site clearing.
- E. Do not commence site clearing operations until temporary erosion- and sedimentation-control and tree protection measures are in place.
- F. Tree-Protection Zones: Protect according to City of Beaverton requirements and as noted on the drawings.
- G. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."
1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect and maintain benchmarks and survey control points from disturbance during construction.
- B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed.
- C. Protect existing site improvements to remain from damage during construction.
1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

- A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.
- B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
- C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
- D. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

- A. Protect trees and plants remaining on-site according to the drawings.
- B. Repair or replace trees, shrubs, and other vegetation indicated to remain that are damaged by construction operations.

3.4 EXISTING 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 utilities indicated to be removed.
 - 1. Arrange with utility companies to shut off indicated utilities.
- C. Locate, identify, and disconnect utilities indicated to be abandoned in place.
- D. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.
- E. Excavate for and remove underground utilities indicated to be removed.

3.5 CLEARING AND GRUBBING

- A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
 - 1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
 - 2. Grind down stumps and remove roots obstructions, and debris to a depth of 18 inches below exposed subgrade.
 - 3. Use only hand methods or air spade for grubbing within protection zones.
- B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.
 - 1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer as specified in Section 31 20 00.

3.6 TOPSOIL STRIPPING

- A. Remove sod and grass before stripping topsoil.
- B. Strip topsoil to depth 6 inches in a manner to prevent intermingling with underlying subsoil or other waste materials.
 - 1. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.
- C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
 - 1. Do not stockpile topsoil within protection zones.
 - 2. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
 - 3. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 STOCKPILING ROCK

- A. Remove naturally formed rocks that measure more than 1 foot across in least dimension. Do not include excavated or crushed rock.
 - 1. Separate or wash off non-rock materials from rocks, including soil, clay lumps, gravel, and other objects larger than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.
- B. Stockpile rock without intermixing with other materials. Cover to prevent windblown debris from accumulating among rocks.

1. Do not stockpile rock within protection zones.
2. Dispose of surplus rock. Surplus rock is that which exceeds quantity indicated to be stockpiled or reused.
3. Stockpile surplus rock to allow later use by the Owner.

3.8 SITE IMPROVEMENTS

- A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
- B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
 1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
 2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.
- B. Burning tree, shrub, and other vegetation waste is permitted according to burning requirements and permitting of authorities having jurisdiction. Control such burning to produce the least smoke or air pollutants and minimum annoyance to surrounding properties. Burning of other waste and debris is prohibited.
- C. Separate recyclable materials produced during site clearing from other non-recyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

SECTION 312000 – EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies requirements for the following:

1. Excavating and filling for rough grading the Site.
2. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and landscape areas.
3. Excavating and backfilling for buildings and structures.
4. Drainage course for concrete slabs-on-grade.
5. Subbase course for concrete walks and pavement.
6. Subbase course for asphalt paving.
7. Subsurface drainage backfill for walls and trenches.
8. Excavating and backfilling trenches for utilities and pits for buried utility structures.
9. Excavating well hole to accommodate elevator-cylinder assembly.

1.2 RELATED DOCUMENTS

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

B. Related Sections

1. Section 311000 Site Clearing
2. Section 312500 Erosion and Sediment Control

1.3 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

- F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
 - 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.
 - 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. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- K. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.4 PREINSTALLATION MEETINGS

- A. Pre-installation Conference: Conduct pre-excavation conference on site.
 - 1. Review methods and procedures related to earthmoving, including, but not limited to, the following:
 - a. Personnel and equipment needed to make progress and avoid delays.
 - b. Coordination of Work with utility locator service.
 - c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
 - d. Extent of trenching by hand or with air spade.
 - e. Field quality control.

1.5 SUBMITTALS

- A. Qualification Data: For qualified testing agency.
- B. Material Test Reports: For each soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D 2487.
 - 2. Laboratory compaction curve according to ASTM D 1557.

1.6 QUALITY ASSURANCE

- A. Blasting: is not allowed.
- B. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

1.7 FIELD CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Improvements on Adjoining Property: Authority for performing earth moving 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. Utility Locator Service: Notify One Call for area where Project is located before beginning earth-moving operations.
- D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures and tree protection are in place.
- E. The following practices are prohibited within protection zones:
 - 1. Storage of construction materials, debris, or excavated material.
 - 2. Parking vehicles or equipment.
 - 3. Foot traffic.
 - 4. Erection of sheds or structures.
 - 5. Impoundment of water.
 - 6. Excavation or other digging unless otherwise indicated.
 - 7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
- F. Do not direct vehicle or equipment exhaust towards protection zones.
- G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils:
1. On-site material is suitable for use as general structural fill provided it is properly moisture conditioned, free of debris, organic material, and meets the specifications provided in OSSC 00330.12 (Borrow Material).
 - a. Estimated optimum moisture content for compaction to be approximately 17 to 19 percent for silt and clay soil, 15 to 20 percent for the sandy soil, and 9 to 12 percent for the gravelly soil.
 - b. Moisture conditioning (drying) will be required to use on-site soil for structural fill.
 - c. All fill containing oversize material (particles over 6 inches in diameter) should be placed in a manner that does not produce voids and bridging. The fill should be placed so that larger pieces are evenly distributed, voids are filled, and rocks should not nest atop one another such that voids are created between the rocks. When rock and soil fill materials are placed at the same time, the materials should be thoroughly mixed. Fill containing oversize material should follow the maximum particles size recommendations provided below.

Table 1. Fill Maximum Particle Size

Depth Below Final Subgrade Maximum Particle Size	
0 to 3 feet	6 inches
3 to 6 feet	8 inches
6 to 10 feet	10 inches
Deeper than 10 feet	12 inches

- C. Unsatisfactory Soils:
1. Unsatisfactory soils include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction or are not free of debris, organic material, and partials over 6 inches in diameter.
- D. Imported Granular Material
1. Structural Fill Material should be pit- or quarry-run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in OSSC 00330.14. The imported granular material should be angular, well graded between coarse and fine material, have less than 5 percent by dry weight passing the U.S. Standard No. 200 Sieve, and have at least two fractured faces.
- E. Stabilization Material
1. Stabilization material used in staging or haul road areas, or as trench stabilization material should consist of 4- or 6-inch minus pit-or quarry-run rock, crushed rock or crushed gravel

and sand and should meet the specifications provided in OSSC 00330.15 (Select Stone Backfill). The material should have a maximum particle size of 6 inches, less than 5 percent by dry weight passing the U.S. Standard No. 4 Sieve, and at least two mechanically fractured faces. The material should be free of organic matter and other deleterious material.

F. Trench Backfill

1. Trench back fill should consist of well-graded granular material with a maximum particle size of 1 ½ inches and less than 5 percent by dry weight passing the U.S. Standard No. 200 Sieve and should meet the specifications provided in OSSC 00405.13 (pipe zone material).

G. Drain Rock

1. For use in Storm Detention System:
 - a. Drain rock should consist of clean, crushed, angular material with a particle size of 1 1/2" – ¾" (AASHTO #4). The material should be free of organic matter and other deleterious material; have less than 2 percent by dry weight passing the U.S. Standard No. 200 Sieve (washed analysis); and have at least two mechanically fractured faces.

H. Aggregate Base Rock

1. Imported granular material used as base rock for building floor slabs and pavements should consist of ¾- or 1 ½- inch minus material and meet the requirements in OSSC 00641 (Aggregate Subbase, Base, and Shoulders). The aggregate should have less than 5 percent by dry weight passing the U.S. Standard No. 200 Sieve.

2.2 GEOTEXTILES

A. Subgrade Geotextile

1. Subgrade geotextile should conform to OSSC Table 02320-1 (Geotextile Property Values for Drainage Geotextile) and OSSC 00350 (Geosynthetic Installation). The geotextile should have a Level "B" certification. A minimum initial aggregate base lift of 6 inches is required over geotextiles.

B. Drainage Geotextile

1. Drainage geotextile should conform to Type 2 material of OSSC Table 02320-1 (Geotextile Property Values for Drainage Geotextile) and OSSC 00350 (Geosynthetic Installation). The geotextile should have a Level "B" certification. A minimum initial aggregate base lift of 6 inches is required over geotextiles.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.
- B. Protect and maintain erosion and sedimentation controls during earth-moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

- A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
 - 1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

3.3 EXPLOSIVES

- A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
 - 2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
 - a. 24 inches outside of concrete forms other than at footings.
 - b. 12 inches outside of concrete forms at footings.
 - c. 6 inches beneath bottom of concrete slabs-on-grade.
 - d. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe trench.

- 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.
1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.
 - a. Intermittent drilling; 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:
 - a. 24 inches outside of concrete forms other than at footings.
 - b. 12 inches outside of concrete forms at footings.
 - c. 6 inches beneath bottom of concrete slabs-on-grade.
 - d. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe trench.

3.5 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
1. Excavations for Footings and Foundations: 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.
- B. Excavations at Edges of Tree- and Plant-Protection Zones:
1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
- B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.
- C. 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.
 1. For pipes and conduit less than 6 inches in nominal diameter, hand-excavate trench bottoms and support pipe and conduit as shown on the drawings.
 2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench as shown on the drawings.
 3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit as shown on the drawings.
- D. Trenches in Tree- and Plant-Protection Zones:
 1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
 2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.

3.8 SUBGRADE INSPECTION

- A. Notify Geotechnical Engineer when excavations have reached required subgrade.
- B. If Geotechnical Engineer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proof-roll subgrade 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. Limit vehicle speed to 3 mph.
 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Geotechnical Engineer, and replace with compacted backfill or fill as directed.
- D. Authorized additional excavation and replacement material will be paid for according to Contract provisions.
- E. 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 2500psi, may be used when approved by Architect.
 - 1. Fill unauthorized excavations under other construction, pipe, or conduit 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. 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, bracing, and sheeting.
 - 7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
- B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.12 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.
- B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill voids with trench backfill material while removing shoring and bracing.
- D. Initial Backfill:
 - 1. Soil Backfill: Place and compact initial backfill of trench backfill, to a height of 12 inches over the pipe.

- a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

E. Final Backfill:

1. Soil Backfill: Place and compact final backfill of trench backfill to final subgrade elevation.

3.13 SOIL FILL

- A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
- B. Place and compact fill material in layers to required elevations as follows:
 1. Under grass and planted areas, use satisfactory soil material.
 2. Under walks and pavements, use satisfactory soil material.
 3. Under steps and ramps, use structural fill.
 4. Under building slabs, use structural fill.
 5. Under footings and foundations, use structural fill.
- C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.14 SOIL MOISTURE CONTROL

- A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 3 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 3 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 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 1557:

1. In all embankment fills and under structures, building slabs, steps, play fields and pavements, scarify and recompact top 12 inches of subgrade and each layer of backfill or fill soil material as recommended below for structural fill.
2. In all embankment fills and under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material as recommended below for structural fill.
3. Non-structural (including landscape) areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at 85 percent.
4. For utility trenches, compact to at least 95 percent of the maximum dry density, as determined by ASTM D 1557, or as required by the pipe manufacturer or local building department.
5. Compacted structural fill as follows: to not less than 95 percent of the maximum dry density for fine-grained soil and 95 percent of the maximum dry density for granular soil, as determined by ASTM D 1557

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.
 1. Provide a smooth transition between adjacent existing grades and new grades.
 2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:
 1. Turf or Unpaved Areas: Plus or minus 1 inch.
 2. Walks: Plus or minus 1/2 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.
- D. Finish Grading: Slope grades to direct water away from building and prevent ponding. Finish grade to elevations noted on the plans and within the following finish grading tolerances:
 1. Landscape or Unpaved Areas: Plus or minus 1/2 inch.
 2. Pedestrian Paved Areas: Plus or minus 1/8 inch. Cross slope shall not exceeds 2% and longitudinal slope (in direction of travel) shall not exceed 5% unless noted on the plans.
 3. Vehicle Paved Areas: Plus or minus 1/4 inch.
 4. Vehicle Paved Areas noted as ADA Accessible Route: Plus or minus 1/8 inch. Cross slope shall not exceeds 2% and longitudinal slope (in direction of travel) shall not exceed 5% unless noted on the plans.
 5. Vehicle Paved Areas noted as ADA Parking Stall or Aisle: Plus or minus 1/8 inch. Slope shall not exceeds 2% in any direction.
 6. Sports Fields, Track, and Tennis Courts: Refer to sports field specification sections.

3.17 BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place base course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place 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 subgrade course under hot-mix asphalt pavement.
 - 3. Shape base course to required crown elevations and cross-slope grades.
 - 4. Place base course that exceed 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.
 - 5. Compact base course within 3 percent of the 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 1557

3.18 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

- A. Place drainage course on subgrades free of mud, frost, snow, or ice.
- B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
 - 1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. 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.
 - 3. 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 1557.

3.19 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:
 - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 - 2. Determine that fill material classification and maximum lift thickness comply with requirements.
 - 3. Determine, during placement and compaction, that in-place density of compacted fill complies with requirements.
- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

- D. Footing Subgrade: All footing subgrades should be evaluated by the Geotechnical Engineer to evaluate bearing conditions. At footing subgrade verification and approval shall be completed by the Geotechnical Engineer.
- E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2937, and ASTM D 6938, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 20,000 sq ft or less of paved area or building slab, but in no case fewer than three tests, or as determined adequate by the Geotechnical Engineer.
 - 2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests, or as determined adequate by the Geotechnical Engineer.
 - 3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests, or as determined adequate by the Geotechnical Engineer.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
 - 1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 - 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Transport surplus satisfactory soil to designated storage areas on Owner's property. Stockpile or spread soil as directed by Architect.

1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 312313 – SUBGRADE STABILIZATION

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for excavating and disposing of unstable materials in excavation areas only and placing subgrade geotextile, and aggregate backfill as shown or directed.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
 - 1. Section 312000 – Earth Moving
 - 2. Section 312500 – Erosion and Sediment Control
 - 3. Section 321123 – Aggregate Base Courses

1.3 MEASUREMENT AND PAYMENT

- A. Measurement – The quantities of subgrade stabilization will be measure on the area basis of subgrade surface are stabilized to the full depth as shown, or directed. The surface area will be determined by horizontal measurements. In areas where directed to stabilize to a depth, the area will be adjusted by converting to an equivalent number of square yards on a proportionate volume basis.
- B. Payment – The accepted quantities of subgrade stabilization will be paid for at the contract unit price, per square yard, for the item “Removal of unsatisfactory soils and replace with satisfactory fill material”. No separate or additional payment will be made for excavation, geotextile, aggregate backfill or water.

1.4 QUALITY ASSURANCE

- A. All work under this section will be subject to the inspection and approval of the Geotechnical Engineer.
- B. The Geotechnical Engineer shall provide recommendation on depth of excavation of the unstable materials.
- C. The Geotechnical Engineer shall provide subgrade compaction testing.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Satisfactory Fill Soils – Section 312000
- B. Imported Granular Material – Section 312000
- C. Stabilization Material – Section 312000
- D. Aggregate Base Rock – Section 312000
- E. Subgrade Geotextile – Section 312000

PART 3 - EXECUTION

- 3.1 Excavation – Excavate unstable material to the lines and grades as directed. Dispose of excavated material at acceptable off site location.
- 3.2 Geotextile – Place geotextile as directed.
 - A. Geotechnical Engineer shall review condition of excavated area prior to placing geotextile.
 - B. Unroll the geotextile in the same direction as fill material placement. If the geotextile shifts or becomes misaligned, realign it and anchor it according to the manufacturer's recommendations.
 - C. Overlap the geotextile as directed.
 - D. Protect the geotextile once installed. Repair or replace damage or torn geotextile.
- 3.3 Backfill – Place backfill material to the lines and grades as directed. Compact backfill as recommended by the Geotechnical Engineer. The Geotechnical Engineer shall review compacted backfill.

END OF SECTION 312313

SECTION 312317 - TRENCHING

PART 1 - GENERAL

1.1 SUMMARY

- A. Trench excavation consists of excavation, bedding, backfill, and removal or disposal of material as necessary in the installation of water lines and, sanitary and storm sewer lines, and appurtenances, conduits, conductors, culverts and any other installation requiring trenching.
 - 1. This work includes, but is not limited to, sheeting, bracing, dewatering, disposal of unsuitable materials, and importing approved bedding or backfill material.
 - 2. All work shall be done in accordance with these Specifications and shown on the Drawings in conformity with the lines, grades, and dimensions.
 - 3. Public Right-of-Way: All public work construction in the public right-of-way shall be in accordance with the applicable requirements of the City of Beaverton Standards.
- B. Unless otherwise provided in the Contract, other work required under this item shall include the removal of structures or portions thereof, grubbing of structure sites which otherwise would not be grubbed, the construction of subsequent removal of shoring or cofferdams, the dewatering of excavated areas, the protection of excavated materials from weather and the placement and compaction of excavated or imported material. Work done under this item shall conform to all federal, state and local safety regulations.

1.2 RELATED DOCUMENTS

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

B. RELATED SECTIONS

- 1. Section 312000 – Earth Moving
- 2. Section 312500 – Erosion/Sedimentation Control
- 3. Section 331100 – Water Distribution Piping
- 4. Section 333100 – Sanitary Sewerage Piping
- 5. Section 334100 – Storm Drainage Piping

1.3 SITE CONDITIONS

- A. Existing Utility Systems: The existing utility systems shown are based on record drawings supplied by the Owner, and “surface” field survey. Prior to constructing any of the utility systems, the Contractor shall “pothole” all connection points and utility crossings to verify inverts, sizes, locations, and potential conflicts. Any discrepancies shall be reported to the Engineer/Architect for resolution or redesign.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Bedding: The bedding of pipes, conduits, cables, and structures shall be as shown on the Plans or as directed by the Architect. The bedding material shall be placed and thoroughly compacted over the full width of the trench. Samples of the proposed materials shall be submitted to the Architect for approval.
- B. Backfill: The backfill for pipes, conduits, cables, and structures shall be as shown on the Drawings or as directed by the Architect. The backfill material shall be placed in maximum eight-inch lifts and thoroughly compacted over the full width of the trench. Samples of the proposed materials shall be submitted to the Architect for approval.
 - 1. Backfill as specified in Section 312000.
 - 2. Granular backfill shall be used in all other locations where native backfill is not designated. Unclassified excavated material used as native backfill shall be earth, sand, gravel, rock, or combinations thereof, free of humus, organic matter, vegetable matter, frozen material, clods, sticks, and debris and containing no stones having a dimension greater than three inches. The materials shall predominate in the finer sizes and, in place, shall present no voids and no isolated points or areas of larger stones which would cause fracture or denting of the utility or structure or subject it to undue stress. Use of the native backfill will not be allowed.
 - 3. Granular backfill shall be used under paved areas, play fields, in trenches in streets, in trenches in public right-of-ways and easements, and other areas subject to wheel traffic, and at structures or as designated on the plans. Granular backfill material shall be 3/4 inch minus crushed aggregate. Top of rock elevation shall be held down at the specified depth in areas designated to receive asphalt paving. All granular backfill shall be placed in maximum eight-inch lifts and compacted to 95% (top 2 feet) and 90% (below 2 feet) maximum dry density per ASTM D 1557 or, as required by the applicable agency in the public right-of-way.

PART 3 - EXECUTION

3.1 CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTIES AND SERVICES

- A. The Contractor shall comply with OAR 952-001-0010 through OAR 952-001-0090 and shall notify all utility companies for line locations 72 hours (minimum) prior to start of work.
- B. At points where the Contractor's operation could cause damage or interference to railway, telegraph, telephone, television, power, oil, gas, water, irrigation, or other private, public or municipal utilities, the Contractor shall suspend work until all arrangements necessary for the protection thereof have been made by the Contractor.
- C. The Contractor shall notify all utility offices which are affected by the construction operation at least 72 hours in advance of excavation. Under no circumstances shall the Contractor expose or

interrupt any utility without first requesting permission and being granted to do so from the affected agency.

1. It shall be the Contractor's responsibility, once permission from the utility has been granted, to locate, if necessary, and expose all of the existing underground utilities in advance of the trenching operation.
- D. The Contractor shall be solely and directly responsible to the Owner and utility companies for any damage, expense, or claims of any kind brought because of injuries, damages or delay which may result from the carrying out of the work to be done under the Contract.
- E. In the event of interruption to domestic water or to other utility services as a result of accidental breakage, or as a result of being exposed, unsupported, or a lack of coordination, the Contractor shall promptly notify the Architect and the agency involved. The Contractor shall cooperate with the said authority in restoration of service as promptly as possible and shall bear any and all costs of repair.
 1. In no case shall interruption of any water or utility service be allowed to exist outside working hours unless prior approval of the Architect or agency involved is granted.
- F. Neither the Owner nor its officers or agents shall be responsible to the Contractor for damages as a result of the location of the underground utilities being other than that shown on the plans or for the existence of underground utilities not shown the plans.

3.2 FIELD RELOCATION

- A. During construction, minor relocations of the line may be necessary. Such relocations shall be made only with approval from the Architect. Unforeseen obstructions encountered as a result of such relocations will not become subject to claims for additional compensation by the Contractor to any greater extent than the original lump sum of the contract or unit price of the utility being installed.

3.3 OPENING TRENCHES

- A. The Contractor shall not begin the trench excavation until the necessary material is on hand to complete the work involved.
 1. The trenches shall be opened in accordance with the lines and grades given for the work, at such times and as far in advance of the work as may be required by the Architect.
 2. Not more than a total of 100 feet of trench shall be opened in advance of the completed utility unless authorized by the Architect. Related structures must be completed and backfilled at the time of line installation.

3.4 BARRICADES, GUARDS AND SAFETY PROVISIONS

- A. To protect persons from injury and to avoid property damage, adequate barricades, construction signs, warning lights, and guards as required shall be placed and maintained during the progress of the work and until it is safe for public use.
 - 1. Watchmen or flag personnel shall be provided as necessary.
 - 2. Rules and regulations of all local and Federal authorities regarding safety provisions shall be observed. The Contractor will be solely responsible for accidents caused by inadequate or insufficient safety provisions

3.5 PAVEMENT REMOVAL

- A. All bituminous and concrete pavements, regardless of the thickness shall be sawcut prior to excavation. Width of the pavement cut shall be equal to the prescribed width of the trench at the ground surface or as shown on the plans.
 - 1. Pavement removed during excavation shall be piled separately from other excavation materials and removed from the site. Pavement shall not be used as backfill material. Uneven pavement edges shall be sawcut before patching the pavement.

3.6 OBSTRUCTIONS

- A. This item refers to obstructions which may be encountered and do not require replacement.
 - 1. Obstructions to the construction of the trench such as tree roots, stumps, abandoned piling, buildings and concrete structures, logs, rubbish, and debris of all types shall be removed without additional compensation from the Owner.
 - 2. The Architect may, if requested, make changes in the trench alignment to avoid major obstructions, if such alignment changes can be made within the perpetual easement and right-of-way and without adversely affecting the intended function of the facility or increase costs to the Owner. Sewer and water trenches must be maintained at a minimum specified separation, however.

3.7 INTERFERING STRUCTURES OR ROADWAYS

- A. The Contractor shall remove, replace and/or repair any damage done by the Contractor during construction to fences, buildings, cultivated fields, drainage crossings, and any other properties at his own expense without additional compensation from the Owner.
 - 1. The Contractor shall replace or repair these structures to a condition as good as or better than their original condition prior to commencing work in the area.
- B. Where paved roadways are cut, granular backfill shall be used as defined above. New pavement shall as specified on the plans and shall not deviate by more than one-quarter inch from the existing finish elevation.

- C. If the Contractor encounters existing structures which will prevent construction and are not adequately shown on the plans, he shall notify the Architect before continuing with the work in order that the Architect may make such field revisions as necessary to avoid conflict with the existing conditions.
 - 1. The cost of waiting or "downtime" during such field revisions shall be borne by the Contractor without additional cost to the Owner or liability to the Architect.
 - 2. If the Contractor fails to so notify the Architect when a conflict of this nature is encountered, but proceed with construction despite this interference, he shall do so at his own risk with no additional payment.

3.8 EASEMENTS

- A. Any damage to private property, either inside or outside the limits of the easements provided by the Owner, shall be the responsibility of the Contractor.
 - 1. Before final payment will be authorized by the Architect, the Contractor will be required to furnish the Owner with written releases from property owners where special agreements or easements have been obtained by the Contractor or where the Contractor's operations for any reason, have not been kept within the construction right-of-way obtained by the Owner.
 - 2. Any such special agreements must be in written form and shall not involve the Owner or Architect as to liabilities in any way.

3.9 GRADES

- A. The bottom of the trench shall be excavated to the lines and grades shown on the plans or established by the Architect with proper allowance for pipe thickness and required bedding. Any trench excavated below grade shall be returned to grade at the Contractor's expense, with fine bedding material.
 - 1. The bedding shall be placed over the full width of the trench in thoroughly compacted layers as previously specified herein. Grades shall be smooth without humps or sags.
- B. The Architect shall be notified with reasonable notice in advance when a section has been excavated and is ready for installation of the utility line or structure. The Architect at that time will make a determination as to the suitability of the excavation foundation and will give notice to the Contractor to proceed or remove unstable material as covered in "Foundation Stabilization."

3.10 WIDTH OF TRENCH

- A. Trenches shall be excavated to a sufficient width to permit proper installation of piping, conduits, or related improvements as shown on the plans or required by local standards and specifications.
 - 1. For the installation of utilities or conduits, the minimum width of trenches shall be as shown on the drawings.

- B. In cases where excessive width of excavation would cause damage to adjacent structure, the trench shall not be excavated in excess of the minimum width as specified herein or detailed on the drawings.

3.11 BORING

- A. Boring may be used as an approved method in lieu of open trench excavation if approved by the Architect. The Contractor shall first show just cause and furnish the Architect with a detailed construction schedule outlining methods, time schedule and proposed safety measures to be incorporated in construction.
 - 1. Upon receiving approval, the Contractor will not deviate from his proposed schedule without first obtaining approval of the Architect and other respective agencies involved in that portion of the work.

3.12 DE-WATERING

- A. Whenever water is encountered in the trench or excavation area, the Contractor shall pump or otherwise dry the bottom of the trench or excavated area before the pipe or conduit installation is commenced.
 - 1. The Contractor shall not allow water encountered in the trench or excavated area to escape down any pipe or conduit in place unless he first obtains written approval from the Architect for this method of de-watering.
 - 2. The Contractor will be responsible for cleaning and/or flushing as required, the complete pipe, conduit, or structure. Any soil, aggregate or other foreign matter in the utility prior to acceptance must be removed at the Contractor's expense prior to final acceptance of the work.

3.13 SHORING AND SHEATHING

- A. The Contractor shall use whatever means necessary to maintain safe working conditions and protect adjacent property and structures from damage due to excavation. The Contractor shall conform to all federal, state and local regulations governing shoring, sheathing, and excavation.
 - 1. When shoring or sheathing is installed, the trench width shall be increased accordingly. The shoring or sheathing shall remain in place until the utility or structure is backfilled to a point where caving could not damage the installation.
 - 2. No payment will be made for shoring or sheathing. All costs involved in placement and removal of shoring and sheathing shall be considered incidental to the work.

3.14 LOCATION OF EXCAVATED MATERIALS

- A. During excavation the Contractor shall locate excavated material so as not to block any public right-of-way, traveled roadways, public or private; and unless otherwise approved by the Architect, roadways shall be kept open to at least one lane of traffic.

1. The Contractor shall store or waste excavated materials only in designated areas unless otherwise approved by the Architect. Utmost care shall be taken to prevent spillage or damage to property adjacent to the project.
- B. Excavated materials unsuitable for backfill as described herein or not required to meet original or specified grades shall be removed as soon as possible or at least by completion of backfill.
 1. No utilities will be considered for payment until these surplus materials have been removed and backfill completed as specified above or as otherwise directed by the Architect. No additional payment will be made to the contractor for disposal of excess materials.

3.15 FOUNDATION STABILIZATION

- A. When, in the opinion of the Geotechnical Engineer, the existing material in the bottom of the trench or excavated area is unsuitable for supporting the pipe, conduit, structure, or related appurtenances, excavation below the flowline of the pipe or base of other structure shall be executed to a suitable depth as directed by the Architect.

3.16 MAINTENANCE OF BACKFILL

- A. Notwithstanding the type of backfill placement, the backfilled trench or excavation surface shall be maintained until all construction has been completed and accepted by the Owner and Architect. This maintenance shall include but not be limited to the addition of backfill in settled areas and surface rock or pavement in roadways to keep the trench reasonably smooth and free from excessive ruts and potholes.

END OF SECTION 312317

SECTION 312500 – EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 SUMMARY

- A. Erosion/Sedimentation Control (ESC) is required on this project. Construction of all erosion control measures shall be in accordance with the City of Beaverton, Clean Water Services, and per DEQ 1200-C permit requirements. Compost based BMP's shall be constructed in accordance with Oregon Department of Transportation Section 00280 – Erosion and Sediment Control specifications and details. All work shall comply with US Army Corps of Engineers and Oregon Department of State Lands Joint Permit and Sections 404 and 401 permit conditions and requirements.
- B. The implementation of the ESC and the construction, maintenance, replacement, and upgrading of these ESC facilities is the responsibility of the Contractor until all construction is completed and approved and the final vegetation/landscaping is established.
- C. This section describes temporary measures and monitoring to control water pollution, soil erosion, and siltation. Erosion, sediment, and pollutant control (EPSC) devices or methods include the use of construction entrances, tree protection fences, diversion dikes, check dams, sediment basins and traps, compost filter sock sediment barriers, compost blanket mulch, gravel, mulches, sediment barriers, grasses, slope drains, and other techniques.
- D. The boundaries of the clearing limits and limits of grading shown on this plan shall be clearly flagged in the field prior to construction. During the construction period, no disturbance beyond the flagged clearing area shall be permitted. The flagging shall be maintained by the Contractor for the duration of the construction.
- E. The ESC facilities shown on this plan and/or details must be constructed in conjunction with all mass grading and site utility construction, in such a manner as to ensure that sediment and sediment laden water does not enter the drainage system, roadways, or violate applicable water standards.
- F. The ESC facilities shown on the plan and/or details are the minimum requirements for anticipated site conditions. During the construction period, these ESC facilities shall be upgraded as needed for unexpected storm events or site conditions to ensure that sediment and sediment-laden water do not leave the site.

1.2 RELATED DOCUMENTS

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

1. Section 311000 – Site Clearing
2. Section 312000 – Earth Moving
3. Section 312317 – Trenching

1.3 SUBMITTALS

A. At the pre-construction meeting, submit the following supplemental EPSC information:

1. Construction start and completion dates.
2. Dates when EPSC measures will be in place.
3. Projected date of removal of erosion control structures (after soil is stabilized by vegetation or pavement).
4. Description of control procedures to prevent the discharge of all wash water from concrete trucks into the storm sewer system.
5. Description of procedures for prompt maintenance or repair of EPSC measures utilized on-site.
6. Description of best management practices that will be used to prevent or minimize storm water from being exposed to pollutants from spills, cleaning and maintenance activities, and waste handling activities. These pollutants include fuel, hydraulic fluid, and other oils from vehicles and machinery as well as debris, leftover paints, solvents, and glues from construction operations.

1.4 QUALITY ASSURANCE

- A. The Contractor is to comply with all applicable local, State, and Federal ordinances, rules, and regulations concerning erosion and sedimentation control and stormwater runoff.
- B. In case of conflict between the above codes, regulations, references, and standards and these specifications, the more stringent requirements shall govern.
- C. Conduct a Preconstruction Meeting onsite as directed by the Owner or Owner's Representative prior to the start of construction.

1.5 PROJECT SITE CONDITIONS

- A. The Contractor to visit the site and verify all existing conditions affecting the work of this section prior to submitting bids or proposals. Additional compensation will not be allowed for revisions or modification of work resulting from failure to verify existing conditions.

PART 2 - PRODUCTS

2.1 GENERAL

- A. All products shall conform to the applicable requirements of City of Beaverton, Clean Water Services, and per DEQ 1200-C permit requirements and Oregon Department of Transportation specifications Section 00280 – Erosion and Sediment Control.

1. Construction Entrance
2. Tree Protection Fence
3. Inlet Protection
4. Compost Filter Sock Sediment Barriers
5. Compost Filter Blanker
6. Tire Washes
7. Concrete Washouts
8. Outlet Protection
9. Plastic Sheeting
10. Diversion Dikes
11. Temporary Seeding
12. Soil Tackifier
13. Erosion Control Blankets
14. Dust Control
15. Temporary Pipe Slope Drains

PART 3 - EXECUTION

3.1 GENERAL

- A. The implementation of the EPSC measures and the construction, performance monitoring, maintenance, replacement, and upgrading of the EPSC measures are the responsibility of the Contractor until all construction is completed and accepted and vegetation/landscaping and paving is established.
- B. The EPSC measures shown on the drawings shall be constructed in conjunction with all clearing, grading, trenching, and earthwork activities and in a manner that ensures that sediment and sediment-laden water do not enter the drainage system, roadways, or violate applicable water quality standards.
- C. The EPSC measures shown on the drawings are the minimum requirements for anticipated site conditions and Contractor methods and sequences. During the construction period, the EPSC measures shall be upgraded as needed for unexpected conditions, storm events, or Contractor methods or sequences and to ensure that sediment and sediment-laden water do not leave the site.
- D. The Contractor shall be responsible for implementing temporary erosion control measures during construction to correct unforeseen conditions. The Contractor shall be responsible for additional erosion control due to the Contractor's negligence, carelessness, or failure to install planned controls as a part of the work.
- E. Implementation, construction, and maintenance of EPSC measures shall be in accordance with the City of Beaverton and Clean Waters Services requirements.
- F. Implementation, construction, and maintenance of EPSC measures shall be in accordance with the Clean Water Services Design AND Construction Standards.
- G. Do not begin soil disturbance activities until perimeter EPSC measures are in place.

- H. The erosion control drawings together with the specifications and 1200-C documents constitute the EPSC plan. A copy of the EPSC plan shall be retained on site and made available to the City of Beaverton and Clean Water Services staff upon request.

3.2 CONSTRUCTION DETAILS

- A. Install and maintain all site public notification signs as shown on the drawings and keep signs easily readable from the public right-of-way throughout the duration of the ground-disturbing activities. Remove and dispose of signs upon completion of work.
- B. No visible or measurable erosion material or pollutant shall exit the construction site. Visible or measurable is defined as:
 - 1. Deposits of mud, dirt, sediment or similar material exceeding 1/2 cubic foot in volume in any area of 100 square feet or less on public or private streets, adjacent property, or into the storm and surface water system, either by direct deposit, dripping, discharge, or as a result of the action of erosion.
 - 2. Evidence of concentrated flows of water over bare soils; turbid or sediment laden flows; or evidence of on-site erosion such as rivulets on bare soil slopes, where the flow of water is not filtered or captured on the site.
 - 3. Earth slides, mud flows, earth sloughing, or other earth movement which leaves the property.
- C. Employ all reasonable means and methods to control or divert upslope stormwater runoff away from cleared and grubbed areas, stockpiled materials, and other disturbed areas that will be open or stockpiled for periods longer than two-weeks.
- D. Construction entrances, exits, and parking areas shall be graveled or paved to reduce the tracking of sediment onto public or private roads. Maintain for the duration of the project.
- E. Unpaved roads on the site shall be graveled or under other effective erosion and sediment control measures, either on the road or down gradient, to prevent sediment and sediment-laden water from leaving the site.
- F. Preserve existing vegetation where practicable and revegetate open areas after grading or construction.
- G. Continuously secure or protect soil stockpiles from runoff and erosion throughout the project with temporary soil stabilization measures or protective cover.
- H. Provide ongoing maintenance, repair, and restoration of EPSC measures to keep them continually functional.
 - 1. The following maintenance activities shall be included:
 - a. Visual or measurable amounts of sediment and pollutants that leave the site shall be cleaned up immediately and placed back on the site or properly disposed. Under no conditions shall sediment be intentionally washed into storm sewers or drainage ways.

- b. Clean catch basin protection when design capacity has been reduced by 50 percent.
 - c. Remove sediment trapped by sediment barriers before it reaches one third of the above-ground barrier height.
 - d. Remove trapped sediments from sediment basins and traps when design capacity has been reduced by 50 percent.
- I. If fertilizers are used to establish vegetation, the application rates shall follow manufacturer's guidelines and the application shall be done in a way that minimizes nutrient-laden runoff to receiving waters.
- J. If construction activities cease for 30 days or more, the entire site shall be stabilized using vegetation or a heavy mulch layer, temporary seeding, or another method that does not require germination to control erosion.
- K. Any use of toxic or other hazardous materials shall include proper storage, application, and disposal.
- L. When trucking saturated soils from the site, either watertight trucks shall be used or loads shall be drained on-site until dripping has been reduced to minimize spillage on roads and streets.
- M. Clean all catch basins and inlets protected from sediment prior to paving and final acceptance. The cleaning operation shall not flush sediment laden water into the downstream system.
- N. EPSC measures installed during construction shall be removed when construction and site disturbance activity are complete and permanent soil stabilization is in place.
- O. Remove and dispose of waste and unused building material.

3.3 WET WEATHER CONSTRUCTION

- A. The Contractor is responsible for all additional measures required during wet weather construction between October 1st and May 30th.

3.4 PROTECTION OF ADJACENT PROPERTY

- A. Protect adjacent properties from land disturbance, erosion, and sedimentation.

3.5 PROTECTION OF JURISDICTIONAL WETLANDS

- A. No work or land disturbance shall occur in jurisdictional wetlands and Clean Water Services vegetated corridors prior to issuance of US Army Corps of Engineers and Oregon Department of State Lands Joint Permit and Clean Water Services Service Provider Letter.
- B. Work shall be completed in compliance with US Army Corps of Engineers and Oregon Department of State Lands Joint Permit and Clean Water Services Service Provider Letter and conditions.

3.6 DISPOSITION OF TEMPORARY MEASURES

- A. All temporary erosion and sediment control measures shall be disposed of within thirty (30) days after final site stabilization and the establishment of paving and final landscaping.
- B. Trapped sediment and other disturbed soil areas resulting from the disposition of temporary measures shall be permanently stabilized to prevent further erosion.

END OF SECTION 312500

SECTION 321123 – AGGREGATE BASE COURSES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for furnishing and placing base course material composed of crushed aggregate.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
 - 1. Section 311000 Site Clearing
 - 2. Section 312500 Erosion and Sediment Control
- C. The referenced specification for this Section is the "Oregon Standard Specifications for Construction" latest edition as prepared by the Oregon Department of Transportation and the Oregon Chapter of the American Public Works Association, and its revisions and supplements.
- D. Public Right-of-Way: All public work construction in the public right-of-way shall be in accordance with the applicable requirements of the City of Beaverton Standards.

1.3 SUBMITTALS

- A. See section 0133000 – Submittals, for submittal procedures.
- B. Materials Sources: Submit name of imported materials source.
- C. Aggregate Composition Test Reports: Results of laboratory test on proposed and actual materials used.
- D. Compaction Density Test Reports.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Aggregate Base Rock:

1. Aggregate base rock below asphalt concrete pavements should be clean, crushed rock or crushed gravel. The base aggregate should contain no deleterious materials, meet specifications provided in ODOT SS 02630.10 – Dense-Graded Aggregate, and have less than 5 percent by weight passing the U.S. Standard No. 200 Sieve.
 2. Base aggregate material shall conform to the requirements of the Standard Specification in areas outside of the public right of way and City of Beaverton Standards for work in the public right-of-way. Refer to the Structural Contract Drawings for additional requirements for aggregate bases under the building.
- B. Certification of Aggregate: Prior to the placing of the aggregate base course material, the Contractor shall produce test results from a certified testing laboratory indicating the suitability of the material.

PART 3 - EXECUTION

3.1 CONSTRUCTION REQUIREMENTS

- A. Aggregate bases shall be placed per the requirements of the Standard Specification and the City of Beaverton Standards.
- B. Compact aggregate base course thoroughly and uniformly to at least 95% of the maximum density as determined by ASTM D1557.

3.2 EQUIPMENT

- A. All equipment necessary for the proper construction of this work shall be in first-class working condition before construction is permitted to start, and all other equipment must be able to produce a product meeting the specifications.

3.3 MAINTENANCE

- A. Following the completion of the base course, the Contractor shall perform all maintenance work necessary to keep the base course in a condition satisfactory for paving.

3.4 FIELD QUALITY CONTROL

- A. The testing agency shall perform field test in accordance with ASTM D2922 to determine compliance with specified requirements for density and compaction of aggregate base material and with ASTM D3017 to determine moisture-content compliance of the installed base course.
- B. Testing frequency shall be not less than one test for every 2,000 square feet of base course material, per layer or lift.

END OF SECTION 321123

SECTION 321216 – ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. Work of this Section consists of furnishing and applying asphalt mixes, tack coats, and placing asphalt concrete pavement in accordance with the applicable requirements of the standards listed below.
 - 1. The asphalt concrete shall be constructed on a prepared underlying course in accordance with these specifications and shall conform to the dimensions and typical cross and with the lines and grades section shown on the plans.
 - 2. The referenced specification for this Section is the "Oregon Standard Specifications for Construction" latest edition as prepared by the Oregon Department of Transportation and the Oregon Chapter of the American Public Works Association, and its revisions and supplements.
 - 3. Public Right-of-Way: All public work construction in the public right-of-way shall be in accordance with the applicable requirements of the City of Beaverton Standards.

1.2 RELATED SECTIONS

- A. Section 312000 – Earthwork.

1.3 PREINSTALLATION MEETINGS

- A. A pre-installation meeting shall be held on-site.
 - 1. Review methods and procedures related to asphalt paving including, but not limited to, the following;
 - a. Review proposed sources of paving material, including capabilities and location of plant that will manufacture asphalt.
 - b. Review requirements for protecting paving work, including restriction of traffic during installation period and for the remainder of the construction period
 - 2. Review methods and procedures related to pavement marking including, but not limited to, the following;
 - a. Pavement aging period before application pf pavement markings.
 - b. Review location of pavement markings.
 - c. Review requirements for protecting pavement markings, including restriction of traffic during installation.

1.4 SUBMITTALS

- A. Include technical data and tested physical and performance properties.
- B. Job-Mix Designs
- C. Material Test Reports
- D. Pavement Marking product information
- E. Pavement Marking: Samples may be requested.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Asphalt Mix Design
 - 1. Provide mix design for 1/2" Dense, Level 2 HMAC as specified on the plans in accordance with the Standard Specifications, and the applicable requirements of the City of Beaverton Standards.
 - 2. Asphalt binder should be performance graded and conform to PG 64-22 or better.
- B. Tack Coat
 - 1. Tack coat material shall be CSS-1 or CSS1h in accordance with the Standard Specifications, and the applicable requirements of the City of Beaverton Standards.
- C. Pavement Markings
 - 1. Traffic striping and markings shall comply with the City of Beaverton Engineering Design Manual, the MUTCD, and the Oregon Supplements to the MUTCD.
 - 2. Pavement Marking Materials shall conform to the specifications in the Oregon Standard Specifications for Construction and Oregon Standard Drawings.
 - 3. Permanent pavement striping and markings within the parking lot shall be white traffic striping paint, Ennis-Flint Paint or approved equal or as noted on the plans.
 - 4. Striping shall conform to ADA guidelines for slip-resistance.

PART 3 - EXECUTION

3.1 PLACEMENT

- A. Tack Coat: Per the Standard Specifications
 - 1. All curbs and longitudinal and transverse joints shall be coated with a sufficient amount of tack coat material prior to placing the adjacent panel. This may be accomplished with hand distribution equipment.

2. Contractor shall be responsible for removing any tack applied to exposed curb faces or other finish surfaces. Tack all surfaces between layers.

B. Asphalt Concrete Paving Surface Course

1. Meet requirements of the Standard Specifications and the applicable requirements of the City of Beaverton.
2. Obtain approval for aggregate base course before placing paving surface course.
3. Place asphalt surface course when temperature shall be 40 degrees F and rising, and when base is dry and free of frost.
4. Place asphalt materials at temperatures between 200 and 250 degrees F.
5. Compact asphalt surface course thoroughly and uniformly to at least 92% of maximum density as determined in conformance with ASTM D 2041, per the requirements of the City of Beaverton Standards.

C. Pavement Marking

1. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect and Owner.
2. Allow paving to age for a minimum of 30 days before starting pavement marking, or as recommended by the manufacturer.
3. Sweep and clean surface to eliminate loose material and dust.
4. Apply paint as recommended by the manufacturer.

3.2 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
 - a. One core sample will be taken for every 1000 sq. yd. or less of installed pavement, with no fewer than three cores taken.
 - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

D. Replace and compact asphalt where core tests were taken.

- E. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

3.3 PROTECTING AND CLEANING

- A. Protect asphalt areas and pavement markings from damage and wear during remainder of construction period.
- B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by pavement marking manufacturer.

END OF SECTION 321216

SECTION 321313 – CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Work consists of the construction of Portland cement concrete sidewalks, driveways, and curbs.
 - 1. The Portland cement concrete shall be constructed on a prepared underlying course in accordance with these Specifications and shall conform to the dimensions and typical cross section and with the lines and grades shown on the plans.
 - 2. The referenced specification for this Section is the "Oregon Standard Specifications for Construction" latest edition as prepared by the Oregon Department of Transportation and the Oregon Chapter of the American Public Works Association, and its revisions and supplements.
 - 3. Public Right-of-Way: All public work construction in the public right-of-way shall be in accordance with the applicable requirements of the City of Beaverton Standards and Specifications.
 - 4. All sidewalks and ramps shall be constructed to American's with Disabilities Act (ADA) standards.
- B. Roadways, sidewalks, curbs, and driveways shall be constructed in accordance with this Specification and related Sections, at the respective locations shown on the plans to the lines, grades, dimensions, and designs shown on the plans or established by the Architect.

1.2 RELATED SECTIONS

- A. Section 312000 – Earth Moving
- B. Section 312317 - Trenching
- C. Section 312500 - Erosion/Sedimentation Control
- D. Section 321123 - Aggregate Base Courses

1.3 PREINSTALLATION MEETINGS

- A. A pre-installation meeting shall be held on-site.
 - 1. Review methods and procedures related to concrete paving including, but not limited to, the following;
 - a. Review proposed sources of paving material, including capabilities and location of plant that will supply concrete

- b. Review requirements for protecting paving work, including restriction of traffic during installation period and for the remainder of the construction period.
- 2. Review concrete forms to ensure ADA tolerances are met.

1.4 SUBMITTALS

- A. Include technical data and tested physical and performance properties.
- B. Job-Mix Designs
- C. Material Test Reports
- D. Tactile warning product information
- E. Wheel Stop product information

1.5 FIELD CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
- B. Cold-Weather Concrete Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
 - 1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow.
 - 3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
- C. Hot-Weather Concrete Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
 - 1. Cool ingredients before mixing to maintain concrete temperature below 90 deg F at time of placement.
 - 2. Cover steel reinforcement with water-soaked burlap, so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

PART 2 - PRODUCTS

2.1 CONCRETE

- A. Concrete Mix Design Constituents shall be per the City of Beaverton Standards and Specifications.
- B. Concrete used under this Section shall have a minimum compressive strength of 4,000psi at 28days per the City of Beaverton Standards and Specifications.

2.2 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
 - 1. Use flexible or uniformly curved forms for curves. Do not use notched and bent forms.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.3 REINFORCEMENT

- A. Reinforcement shall be per the details shown on the plans.

2.4 WHEEL STOPS

- A. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 6 inches high by 6 inches wide by 72 inches long. Provide drainage slots on underside and holes for anchoring to substrate.
 - 1. Dowels: Galvanized steel, 1/2-inch diameter, 24-inch length.

2.5 TRUNCATED DOMES

- A. Place pre-cast truncated dome detectable warning tile in the lower 2 feet of all pedestrian ramp throats per plans and details. The truncated dome detectable warning surface must be installed during the concrete pouring. Once the concrete is graded, smoothed, and finished, place the detectable warning tile in the lower 2 feet of the pedestrian ramp, per manufacturer's recommendations.
 - 1. Color shall be Federal Yellow per Federal Standard 595b Table IV, color no. 33538.
 - 2. Detectable warning tile shall be compliant with ADA Standards for Accessible Design, City of Beaverton, and Oregon Transportation Commission Standards for Accessible Parking Places.

PART 3 - EXECUTION

3.1 GENERAL

- A. All Work shall comply with Sections 00480 and 00759 of the Standard Specification, and the requirements of the City of Beaverton Standards.

3.2 PREPARATION FOR HANDLING AND PLACEMENT OF CONCRETE

- A. In preparation for placing of concrete, all sawdust, chips, and other construction debris or extraneous matter shall be removed from the interior of the forms or base. Any standing water shall be removed and a firm, stable base verified.
- B. Struts, stays, and braces serving temporarily to hold the forms in the correct shape and alignment prior to the placing of concrete shall be removed when the concrete placing has reached the elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

3.3 PREPARATION OF BASE

- A. Areas on which sidewalks, curbs, and driveways are to be constructed shall be brought to proper lines and grade and compaction specified on the Drawings. The base shall be moistened before Portland cement is placed thereon and shall also be moist and firm at the time the concrete is placed.

3.4 JOINING NEW TO EXISTING CONCRETE

- A. Construct suitable connections between new and existing concrete where the new construction abuts the existing concrete. Unless shown or directed otherwise, furnish and place minimum 3/4 inch thick preformed expansion joint filler between new and existing concrete.

3.5 REINFORCEMENT, DOWELS AND TIE BARS

- A. Furnish and place reinforcement, dowels and tie bars according to 00755.43 and as shown or directed.
- B. Provide dowels with "slip sleeves" and place as load transfer devices where shown. Place dowels without "slip sleeves" as fastenings or ties between new and existing underlying concrete when shown.

3.6 JOINTS

- A. Expansion Joints –Place expansion joints adjacent to driveway approaches, utility vaults, drainage inlets, sidewalk ramps, curb joints, and at points of tangency, and at spacing not to exceed 200 feet.

- B. Contraction Joints – Place contraction joints at 15 foot maximum spacing.

3.7 TESTING AND INSPECTION

- A. Slump tests, air entrainment, and cylinder tests may be conducted on poured in place concrete at the frequency determined by the Owner. All tests, initiated by the Owner, will be at the Owner's expense. The Owner will designate an independent testing laboratory, and the contractor shall notify the laboratory 48 hours prior to all pours so that tests can be scheduled and performed.

3.8 CONCRETE CONSOLIDATION

- A. Concrete, during and immediately after depositing, shall be thoroughly consolidated. The consolidation shall be done by mechanical means, such as spading, or high frequency vibrators, and shall ensure smooth surfaces and dense concrete along form surfaces or in corners, etc.

3.9 PROTECTION

- A. The completed concrete surface shall be protected from damage until the project is accepted. The Contractor shall repair damaged concrete and clean concrete discolored during construction. Surfaces that are damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed portions shall be disposed of off the project site by the Contractor at no additional cost to the Owner.

END OF SECTION 321313

SECTION 323113 - CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Fence framework, fabric, and accessories
- B. Excavation for post bases; concrete foundations for posts
- C. Manual gates and related hardware.

1.2 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete anchorage for posts.

1.3 REFERENCE STANDARDS

- A. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric; 2011a.
- B. ASTM F567 - Standard Practice for Installation of Chain-Link Fence; 2011.
- C. ASTM F668 - Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric; 2011.
- D. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures; 2013.
- E. CLFMI CLF-SFR0111 - Security Fencing Recommendations; 2014.

1.4 SUBMITTALS

- A. Product Data: Provide data on fabric, posts, accessories, fittings and hardware.
- B. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, and schedule of components. See CLFMI CLF-SFR0111 for planning and design recommendations.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Provide all fabric, posts, rails, rods, bars, fittings, and hardware as required to make a complete installation.
- B. Posts, Rails, and Frames:
 - 1. Posts and rails 4 inches and under to meet ASTM F 1043 Group 1-C Schedule 40 hot-dipped galvanized steel pipe, welded construction.
 - 2. Posts and rails over 4 inches to meet ASTM F 1043 Group 1-A Schedule 40 hot-dipped galvanized steel pipe, welded construction.
- C. Wire Fabric: ASTM A 392 zinc coated class 1 steel chain link fabric manufactured by Pacific Fence and Wire Company or approved equal.
- D. Vinyl Coated Fabric: Meet ASTM F 668 Class 2B, Fused-Bonded, as manufactured by Pacific Fence & Wire Company or approved equal.
- E. Fence Fittings: Meet ASTM F 626 (Domestic).
- F. Concrete: Type specified in Section 033000.

2.2 COMPONENTS FOR FENCES 6 FEET TALL

- A. Line Posts: 6 foot fence or less: 2.38 inch outside diameter.
- B. Corner and Terminal Posts: 3.5 inch outside diameter.
- C. Gate Posts: 3.5 inch outside dimension; square posts.
- D. Top, Bottom, and Brace Rail: 1.66 inch outside diameter, plain end, sleeve coupled.
- E. Gate Frame: 1.66 inch diameter for welded fabrication.
- F. Fabric: 2 inch diamond mesh interwoven wire, 6 gage, 0.1620 inch thick, top selvage knuckle end closed, bottom selvage twisted tight.
- G. Tension Bars: 3/16 inch x 3/4 inch x fabric height less 2 inches.
- H. Heavy Brace and Tension Bands: 1/8 inch x 1 inch.
- I. Vinyl coated fence ties: 9-gauge finish with an 11-gauge core wire.
- J. Tension Wire:
 - 1. Vinyl coated tension wire to be 6-gauge finish/9-gauge core and will be Marcellled and meet ASTM F 1664 Class 2a

- K. Galvanized Hog Rings: 9-gauge Class III.
- L. Vinyl Coated Hog Rings: 9-gauge finish.
- M. Truss Rods: 5/16 inch outside diameter minimum.

2.3 ACCESSORIES

- A. Caps: Cast steel galvanized; sized to post diameter, set screw retainer.
- B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings; galvanized steel.

2.4 GATES

- A. Gates to comply with ASTM F 1043 Group 1-C, ASTM F 900, and have commercial grade hardware.
- B. Hardware for Single Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches high, 3 for taller gates; fork latch with gravity drop and padlock hasp; keeper to hold gate in fully open position.
- C. Hardware for Double Swinging Gates: 180 degree hinges, 2 for gates up to 60 inches high, 3 for taller gates; drop bolt on inactive leaf engaging socket stop set in concrete, active leaf latched to inactive leaf preventing raising of drop bolt, padlock hasp; keepers to hold gate in fully open position.
- D. Panic Hardware: Weatherized exit bar suitable for outdoor use with 18 inch tall powder coated (black) steel C-channel mounting plate. Install lever style handle for outside access.
 - 1. Approved Manufacturer: Von Duprin XP99, or approved panic with lever
 - 2. Approved Product: LD-XP99-L-06-WH x 626

2.5 FINISHES FOR ALL FENCE MATERIALS

- A. Components and accessories: Powder coat all posts, rails, frames, components, and accessories.
- B. Fabric: Vinyl coated over coating of 2.0 oz/sq ft galvanizing.
- C. Color(s): Black.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install framework, fabric, accessories and gates in accordance with ASTM F567.

- B. Place fabric on outside of posts and rails, unless indicated otherwise.
- C. Set intermediate posts plumb . Slope top of concrete for water runoff.
- D. Brace each gate and corner post to adjacent line post with horizontal center brace rail. Install brace rail one bay from end and gate posts.
- E. Provide top rail through line post tops and splice with 6 inch long rail sleeves.
- F. Install center brace rail on corner gate leaves.
- G. Fabric ends shall occur only at terminal, corner, or pull posts.
- H. Do not stretch fabric until concrete foundation has cured 28 days.
- I. Runs of fence more than 500 feet in length shall have at least one intermediate 3 inch outside diameter pull post with braces in two directions. Maximum distance between intermediate posts is 500 feet.
- J. Position bottom of fabric 1 inch above finish grade.
- K. Space hog rings at a maximum spacing of 24 inches.
- L. Install fence ties as outlined in ASTM standard.
- M. Attach fabric to end, corner, and gate posts with tension bars and tension bar clips with maximum 12 inches on center.
- N. Install hardware and gate with fabric to match fence.
- O. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings.
- P. Fence ties and fabric edges shall be appropriately knuckled and tied back so that there are no protruding sharp edges.

3.2 TOLERANCES

- A. Maximum Variation From Plumb: 1/4 inch.
- B. Maximum Offset From True Position: 1 inch.

END OF SECTION 323113

SECTION 323119 - DECORATIVE METAL FENCES AND GATES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Decorative metal fences and gates.

1.2 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 08 71 00 - Door Hardware.

1.3 REFERENCE STANDARDS

- A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2015.
- B. ASTM F2408 - Standard Specification for Ornamental Fences Employing Galvanized Steel Tubular Pickets; 2016.

1.4 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Submit manufacturer's data sheets on each product to be used, including:
 - 1. Preparation instructions and recommendations.
 - 2. Storage and handling requirements and recommendations.
 - 3. Installation methods.
- C. Shop Drawings:
 - 1. Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.
- D. Manufacturer's specifications.
- E. Installer's Qualification Statement.
- F. Manufacturer's Warranty.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum five years documented experience.
- B. Installer Qualifications: Experienced with type of construction involved and materials and techniques specified and approved by fence manufacturer.

1.6 DELIVERY, STORAGE AND HANDLING

- A. Store materials in a manner to ensure proper ventilation and drainage. Protect against damage, weather, vandalism and theft.

1.7 WARRANTY

- A. All structural fence components (rails, pickets, and posts) shall be warranted for 10 years. Warranty shall cover any defects in material finish, including cracking, peeling, chipping, blistering, or corroding.
- B. Reimbursement for labor necessary to restore or replace components that have been found to be defective under the terms of manufactures warranty shall be guaranteed for five (5) years from date of original purchase.

PART 2 PRODUCTS

2.1 DECORATIVE METAL FENCES

- A. Fences: Complete factory-fabricated system of posts and panels, accessories, fittings, and fasteners; finished with electrodeposition coating, and having the following performance characteristics:
 - 1. Capable of resisting vertical load, horizontal load and infill performance requirements for fence categories defined in ASTM F2408.
- B. Steel: ASTM A653/A653M; tensile strength 45,000 psi, minimum.
- C. Posts: 2-1/2 inch square; 16 gauge.
- D. Gate posts: 3 inch x 12 gauge.
- E. Hinges: Heavy commercial self-closing hinge kit.
- F. Brackets: Line brackets at line posts. Universal brackets at ends.
- G. Panic Hardware: Weatherized exit bar panic hardware suitable for outdoor use with 18 inch tall powder coated (black in color) steel C-channel mounting plate. Install lever style handle for outside access.

1. Approved Manufacturer: Von Duprin XP99, or approved.
- H. Gate Operating Hardware: Von Durpin panic with lever; Model: LD-XP99-L-06-WH x 626
- I. Color: All fence components black in color, except Panic and Gate Operating Hardware.

2.2 APPROVED PRODUCT:

- A. Montage Plus Majestic 2 Rail by Ameristar Fence @ 1-888-333-3422.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Do not begin installation until substrates have been properly prepared.
- B. If substrate preparation is the responsibility of another installer, notify Owner's Representative of unsatisfactory preparation before proceeding.

3.2 PREPARATION

- A. Clean surfaces thoroughly prior to installation.

3.3 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Set fence posts as shown on the drawings. Generally fence posts should be equally spaced between end or gate posts as shown on drawings. Cut fence following manufacturer's instructions. Do not exceed the manufacturer's recommended spacing.
- C. When cutting rails immediately seal the exposed surfaces by:
 1. Removing metal shavings from cut area.
 2. Apply zinc-rich primer to thoroughly cover cut edge and drilled hole; allow to dry.
 3. Apply two coats of custom finish spray paint matching fence color.
- D. Space gate posts according to the manufacturers' drawings, dependent on standard out-to-out gate leaf dimensions and gate hardware selected.
 1. Base type and quantity of gate hinges of the application; weight, height, and number of gate cycles.
 2. Identify the necessary hardware required for the application on the manufacturer's gate drawings.

3. Provide gate hardware by the manufacturer of the gate and install in compliance with manufacturer's recommendations.

3.4 ERECTION TOLERANCES

- A. Maximum Variation From Plumb: 1/4 inch.
- B. Maximum Offset From Indicated Position: 1/4 inch.

3.5 CLEANING

- A. Leave immediate work area neat at end of each work day.
- B. Clean jobsite of excess materials; scatter excess material from post hole excavations uniformly away from posts. Remove excess material if required.
- C. Clean fence with mild household detergent and clean water rinse well.
- D. Touch up scratched surfaces using materials recommended by manufacturer. Match touchup paint color to fence finish.

3.6 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair, or replace damaged products before Date of Substantial Completion.

END OF SECTION 323119

SECTION 328000 - IRRIGATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Installation of Backflow Prevention Assembly and related appurtenances.
- B. Installation of an electric solenoid controlled underground sprinkler system of PVC pipe and fittings with pop-up heads.
- C. Installation of Irrigation Control Assembly and control wires, at new shrub and lawn zones.

1.2 RELATED REQUIREMENTS

- A. Section 015639 - Temporary Tree and Plant Protection
- B. Division 26 - Electrical
- C. Division 31 - Earthwork
- D. Section 32 90 00 - Planting

1.3 REFERENCE STANDARDS

- A. ASTM D1784: Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
- B. ASTM D1785: Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- C. ASTM D2464 - Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
- D. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- E. ASTM D 2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems; 2004 (Reapproved 2009).

1.4 PROTECTION

- A. Protect existing improvements and growth in areas to remain undisturbed until completion of project. Leave area in similar condition as found.

- B. Protect utilities and maintain in continuous operation or in operational condition during work. Repair damage to known utilities at Contractor's expense.
- C. Use means necessary to protect materials of this Section before, during, and after installation and to protect installed Work and materials of other trades. In the event of damage immediately make repairs and replacements as directed by Owner's Representative.

1.5 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the work with other trades affecting and affected by Work of this Section.
- B. Preinstallation Meeting: Convene one week (minimum) prior to commencing work of this Section to coordinate utility marking procedures.

1.6 SUBMITTALS

- A. Product Data: Submit manufacturer's printed data covering products and installation instructions.
- B. Quality Assurance Data: Submit license information and project references including name and location of previous projects, date of installation, square footage of areas with irrigation work, description of irrigation system, and Owner's contact information.
- C. Record Documents: Record actual locations of installed irrigation components on a clean set of plans. Use white out and red ink to legibly re-draft as-built information.
 - 1. Produce and keep current throughout the project.
 - 2. Indicate two dimensions for valves, stub outs, and main line T's, L's, ends, elbow's, and change in direction.
 - 3. Include spare parts list and local source for replacement parts.
 - 4. Submit to Owner's Representative for approval.
 - 5. Final submittal shall include fully laminated, clean print of final irrigation Record Drawing, reduced by 50%, with zones clearly color-coded for posting near automatic controller.
- D. Operation and Maintenance Data:
 - 1. Provide written instructions at System Demonstration for operation and maintenance of system and controls, seasonal activation and shutdown, and manufacturer's parts catalog.
 - 2. Submit chart showing actual precipitation rates for each zone.
 - 3. Prepare a program for the irrigation controller for Spring/Summer; Summer; Summer/Fall using historical weather data and averages. Include start times, watering duration, day of week, repeat cycle mode, program mode, precipitation rates in inches per hour, and application quantities. Coordinate operation and programming with Owner's Representative.
- E. Maintenance Materials: Provide the following for Owner's use in maintenance of project.

1. Extra Valve Keys for Manual Valves: Two.
2. Extra Valve Box Keys: Two.
3. Wrenches: One for each type head core and for removing and installing each type head.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing Work of this Section who has successfully completed a minimum of 5 comparable scale projects and have the following licenses:

1. For Irrigation Work:
 - a. Valid Oregon Landscape Contractors license.
 - b. Valid Oregon Landscape Business license.
2. For Plumbing Work:
 - a. Valid Oregon Plumbing license.
 - b. Valid Oregon Landscape Contractor license.
3. Successfully completed at least 5 comparable scale projects.
 - a. Submit names, addresses, dates, Owners and locations of previous projects if requested by Owner's Representative.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products in original unopened packaging with legible manufacturer's identification.
- B. Comply with manufacturer's recommendations for storage and protection.
1. Store in a cool, dry place out of direct sunlight.
 2. Protect from damage by the elements and construction procedures.
 3. Store plastic pipe on firm, level supports.
 4. Store plastic pipe cement in cool location.

1.9 ENVIRONMENTAL CONDITIONS

- A. Temperature of mating surfaces of plastic pipe and fittings to be between 40 degrees Fahrenheit and 100 degrees Fahrenheit. Perform no PVC Solvent welding in rainy weather except under cover.

1.10 REVIEWS

- A. Request the following reviews by the Owner's Representative two days (min.) in advance:

1. Irrigation Head Layout Review
2. Pressure Test and Mainline Installation
3. System Review
4. System Demonstration to Owner

- B. Coordinate Reviews to coincide with regular progress meetings where possible.
- C. Work shall not be covered or enclosed until it has been inspected, pressure tested, and approved by the Owner's Representative.

1.11 MAINTENANCE

- A. During period between system installation and Final Completion provide maintenance to assure proper operation of the irrigation system.
- B. Provide 90 day maintenance period following Final Completion. Operate, review, and maintain irrigation system.

1.12 WARRANTY

- A. Warranty period shall be one year following Final Completion or one full operating season following Final Completion, whichever is longer.
- B. Contractor guarantees materials furnished under this Contract will be as specified and the Work will be free of defects in compliance with the Contract Documents.
- C. Irrigation system must be in proper working condition at the end of the warranty period. At no additional cost to the Owner replace Work of this Section as necessary to restore system to proper working condition following the Contract Documents.
- D. Visit and inspect Work at least once a month during warranty period and notify Owner's Representative in writing of any observed conditions requiring attention. Failure to provide such notification renders deficiencies the Contractor's responsibility to rectify.
- E. Contractor is not responsible for loss or damage to Work of this Section caused by unusually extreme weather, vandalism, or lack of Owner's maintenance during warranty period.

PART 2 - PRODUCTS

2.1 IRRIGATION SYSTEM MATERIALS

- A. Use only new materials of brands and types shown on Drawings or specified herein.
- B. Similar materials must be products of one manufacturer unless otherwise approved.
- C. Substitutions: See Section 012500 - Product Requirements.

2.2 PIPE MATERIALS

- A. Mainline Pipe and Lateral Line Pipe: Schedule 40 PVC Pipe, Type 1, normal impact: IPS, NSF approved conforming to ASTM D1784, ASTM D1785.
- B. Irrigation Sleeve: Class 200 PVC Pipe, Type 1, normal impact: IPS, NSF approved conforming to ASTM D1784, ASTM D2241.
- C. Threaded Fittings including PVC nipples and unions: Schedule 80 PVC with molded threads.
- D. Other Fittings: Type and style of connection to match pipe.
- E. Risers: One piece schedule 80 gray PVC Pipe, Type 1, threaded at both ends conforming to ASTM D1784 and ASTM D2464. No snap-risers.
- F. Flex Riser Assembly: 18 inch minimum, 3 feet maximum Swing-Pipe with transfer barb 90 degree ells at both ends and a marlex ell below the irrigation head.
- G. Electrical Conduit and Fittings:
 - 1. Underground: Plastic, Class 3, Federal Specification W-C-1094.
 - 2. Above Ground: Aluminum, Federal Specification WW-G-540.
- H. PVC Solvent Cement: NSF approved solvent for both Schedule 80 and Schedule 40 pipe and fittings with NSF approval for Type I and Type II PVC.
 - 1. Up to 2" pipe size: Medium Body PVC cement for pipe and fittings.
 - a. Weld-On 725, or approved equal.
 - 2. Larger than 2" pipe size: Heavy Body PVC cement for pipe and fittings.
 - a. Weld-On 711 Gray Glue, or approved equal.
- I. PVC Cleaner and Primer:
 - 1. IPS Weld-on P-75, or approved equal.

2.3 VALVES

- A. Control Valve Assembly:
 - 1. Automatic Control Valve: Globe type, 200 psi rated, threaded connections with cross type operating handle designed to receive operating key. Size according to Valve Schedule on Drawing. Include adjustable pressure regulator feature at each valve.
 - a. Approved Products:
 - 1) Rain Bird PEB-PRS-D Series at zones with spray heads, or approved equal.

- b. Substitutions: See Section 016000 - Product Requirements.
 - 2. Shut Off Valve: USA manufactured gate valve. 135 psi cold water rated constructed of brass or bronze on 2 inch and under valves with bronze wheel handle.
 - a. Approved Products: Nibco T-113, or approved equal.
 - B. Quick Coupling Valves:
 - 1. Approved Products: Rain Bird 44 RC, or approved equal.
 - C. Master Valve: 24V AC, normally open and flanged at both ends.
 - 1. Approved Products:
 - a. Size: 2 inch.
 - b. Model 200-BPE by Rainbird, or approved equal.
 - D. Flow Sensor: PVC tee type sensor.
 - 1. Approved Products: Model No. FS200P by Rain Bird, or approved equal.
 - E. Manual Drain Valve Covers: Weathermatic model number 960L, locking cover, or approved equal.
 - F. Manual Drain Valve: Bronze angle manual valve with non-floating seat disk that allows positive drainage.
 - 1. Approved Products: Buckner 2200 series, or approved equal.
 - G. Backflow Preventers:
 - 1. Approved Products:
 - a. Size: 2 inch.
 - b. Model # DC4A-118-T2 by Apollo.
- 2.4 VALVE BOXES
- A. Valve box of suitable size with tee top type lid bolted closed.
 - 1. Black box and green lid at lawn areas.
 - 2. Black box and brown lid at plant bed areas.
 - B. Install valves in the following valve boxes:
 - 1. Control Valve Assembly: (2) Carson 1419-12, T-Lid, or approved equal.
 - 2. Quick Coupling Valves: Carson 910-12, T-Lid, or approved equal.
 - 3. Manual Drain Valves: Carson 910-12, or approved equal.

2.5 IRRIGATION HEADS

- A. Makes and models shown on Drawings, or approved equal.

2.6 WIRE

- A. Zone Control Wire (2-Wire): 2 wire, 14 AWG Double Jacket Insulated, Dual Conductor – solid core.
 - 1. Approved products:
 - a. Maxi Wire by Rainbird, or approved equal.
 - b. Paige Electric, Model # P7350D, or approved equal.
- B. Wire from Controller to Master Valve: Install according to manufacturer's wire schedule for valve specifications. 12 gauge minimum, type AWG, bearing U.S. approval, yellow wire color.
- C. Communication Wire: Install according to manufacturer's central control requirements. Wire from controller to flow sensor must be a single, unspliced length.
 - 1. 19 gauge, PE 39 cable, 6 pair.
- D. Wire Connections: Direct bury splice Kit.
 - 1. DBR/Y by 3M, or approved equal.
 - 2. DB Series by Rainbird, or approved equal.
- E. Utility Locate Wire: 14 gauge minimum, type AVG-UF, bearing U.S. approval, blue in color.

2.7 TWO WIRE DECODERS

- A. 1 each at master valve and control valves: FD-101TURF by Rainbird, or approved equal.
- B. 1 needed at every 8 devices or every 500 feet: LSP-1TURF by Rainbird, or approved equal.
- C. 1 each at flow sensor: SD-210TURF by Rainbird, or approved equal.

2.8 IRRIGATION CONTROLLER - ACMA

- A. Rainbird ESP-LXD two wire decoder controller with IQ Network Communication Cartridge.
 - 1. ESPLXD-SM75: 75-station module for ESP-LXD.
 - 2. IQ-NCC: Network Communication Cartridge (Cellular).
 - 3. Isolation-Flow Sensor Relay Circuit: ISF-302 ISOFLOW, by Creative Sensor Technology.
 - 4. LXMMSS Stainless steel controller cabinet.

2.9 IRRIGATION CONTROLLER - PAC

- A. Rainbird ESP-LXMEF irrigation controller with IQ Network Communication Cartridge.
 - 1. ESPLXMEF-SM36: 36-station module for ESP-LXMEF
 - 2. IQ-NCC: Network Communication Cartridge (Cellular)
 - 3. LXMSSS Stainless steel controller cabinet.

2.10 BACKFILL MATERIALS

- A. Pea Gravel: 3/4 x 1/2 inch washed round rock.
- B. Sand: Clean, fill sand free of clay, rocks, organic matter, or other deleterious material.
- C. Topsoil or Loam: See Section 329000 - Planting.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that required utilities and sleeves are available, in proper location, and ready for use. Verify location, type, size, psi, and GPM of existing water lines, meters, and sleeves.
- B. Verify that surfaces and structures to receive Work are accurately sized and located, sound, secure, true, complete, and otherwise properly prepared.
- C. Verify electrical service, communication wire, and conduit for Irrigation Controller is properly sized and located.

3.2 PREPARATION

- A. System layout is diagrammatic. Route piping to avoid plants, ground cover, and structures. If field measurements differ slightly from Drawings modify work for accurate fit. If measurements differ substantially notify Owner's Representative prior to installation.
- B. Review layout requirements with other affected work. Coordinate locations of sleeves under paving to accommodate system and piping to minimize conflict with other work.
- C. Coordinate connections to existing irrigation system, including system shut down, new connections, system re-start, and scheduling of new irrigation zone run times with Owner's Representative.
- D. Irrigation Head Layout Review: Install flags at locations of irrigation heads and components shown on Drawings. Obtain Owner's Representative's approval and make adjustments to locations as directed. Coordinate marking of pipe trenches and location of valves prior to executing Work.

3.3 CUTTING OF PAVEMENT AND REPAIR

- A. Do no cutting of pavement for installation of Work without BSD Representative's approval.

3.4 BACKFLOW PREVENTION DEVICE INSTALLATION

- A. Install where shown on Drawings. Follow applicable codes and in accordance with manufacturer's directions when making supply and central control component connections. Coordinate with other trades.
- B. Coordinate connection with other trades.

3.5 MASTER VALVE AND FLOW SENSOR INSTALLATION

- A. Install where shown on Drawings in accordance with manufacturer's directions when making supply and central control component connections.

3.6 TRENCHING

- A. Excavate trenches with uniform bottom and remove rocks and sharp objects to provide firm, even, clean base for pipe. Width of trench to be 1.5 times the outside diameter of the pipe.
- B. Trench Depth:
 - 1. Minimum Cover Over Installed Mainline Piping: 18 inches.
 - 2. Minimum Cover Over Installed Lateral Line Piping: 12 inches.
 - 3. Minimum Cover Over Installed Sleeves in Roadway: 24 inches.
 - 4. Minimum Cover Over Installed Sleeves at other paving: 6 inches from bottom of paving.
- C. More than one pipe is permitted in the same trench provided that:
 - 1. Two pipes may be stacked vertically if 4 inches of Sand separates them.
 - 2. Three or more pipes must be laid 2 inches apart horizontally.
- D. Where excavation is performed to excess levels backfill with Sand to proper levels.
- E. Keep trenches dry and frost free. Provide and operate pumping equipment to keep excavations free from standing water.
- F. Protect existing vegetation to remain. Cut no roots over two inches in diameter without approval of BSD Representative. Make cuts clean, straight, at right angles to roots. Paint cuts over 1-1/2 inches diameter with approved tree paint. Repair or replace damaged plant material.

3.7 SLEEVE INSTALLATION

- A. Sleeves may be jacked or pulled but cover requirements must be maintained. Jacking of PVC pipe is not permitted in rocky or bar run fills where there is potential for damage to pipes.

- B. Extend sleeves 12 inches beyond pavement edge or curb.
- C. Install level and perpendicular to sidewalks and pavement unless shown otherwise on drawings.
- D. Provide markers where sleeve ends are concealed.

3.8 PIPE BEDDING

- A. Mainline: Provide uniform bearing surface of Sand, 4 inches minimum depth, free of rocks and sharp objects under entire length of pipe.
- B. Lateral Line: Provide uniform bearing surface of clean topsoil, loam, or Sand. If rock or other deleterious materials are encountered bed pipe with 4 inches of Sand on all sides.

3.9 PIPE INSTALLATION

- A. Irrigation lines may be jacked or pulled but cover requirements must be maintained. Jacking of PVC pipe is not permitted in rocky or bar run fill or where there is potential damage to pipes.
- B. Install pipe in accordance with manufacturer's instructions and with the following minimum clearances around pipe:
 - 1. 2 inch diameter and smaller: 2 inches
 - 2. 2-1/2 inch diameter and larger: 4 inches
 - 3. Between irrigation and other utilities: 1 foot
- C. Threaded Plastic Pipe Installation:
 - 1. Do not use solvent cement on joints.
 - 2. Wrap threaded joints with teflon tape. Minimum 4 wraps of tape.
- D. Cemented Plastic Pipe Installation:
 - 1. Cut ends square using approved pipe cutter and bevel cuts with deburring tool.
 - 2. Clean pipe of scale, sand, dirt, etc. prior to assembling.
 - 3. Avoid using an excess amount of primer and cement when making joints; particularly on the inside of female pipe ends and fittings.
 - 4. Wipe off excess cement continuously as it appears on the surface of the pipe after making joints.
 - 5. Allow fifteen minutes of cure time on joints before moving or handling. Assemble pipe before lowering into trench.
 - 6. Snake lines to allow for contraction.
 - 7. Transition pipe sizes at fittings and not bell end of pipes.
 - 8. Install thrust blocks at 90 degree corners and tees.

3.10 THRUST BLOCK INSTALLATION

- A. Install 2500psi thrust block at mainline pipe corners, tees, ells, and stub outs.
 - 1. Pipe 2 - 3 inches in diameter: 1 cubic foot.

3.11 VALVE INSTALLATION

- A. Install plumb and square, as detailed, and according to manufacturer's specifications.
- B. Manual Drain Valves:
 - 1. Install at mainline low points and at outlet of control valves where laterals run uphill.
 - 2. Record locations on as-built drawings.
 - 3. Provide suitable length of 2" class 200 PVC pipe to fit over drain valve stem and install locking valve cap flush with finish grade. Provide two valve-operating keys of type and length required to operate valve.
- C. Quick Coupling Valve: install on 1" prefabricated swing joint assemblies.
- D. Install 1 valve in each valve box assembly.
- E. Valve Sump: Install a minimum of 2 cubic feet of Pea Gravel below each valve. Allow for 4 inches clearance between bottom of valve and valve sump.

3.12 VALVE BOX INSTALLATION

- A. Install plumb and square with adjacent construction with one valve in each valve box assembly.
- B. At Control Valve Assemblies bolt two valve boxes together as detailed.
- C. Permanently label valve type and zone number on inside of valve box lid.
- D. Set top of valve boxes flush with lawn or mulch at plant beds unless otherwise noted.
- E. Provide 12 square inches (min.) of support on each side of valve box as detailed.

3.13 CONTROL WIRE INSTALLATION

- A. Install wires below irrigation mainline with multiple wires bundled together at 5 foot maximum intervals in a continuous run. Notify Owner's Representative for approval prior if splices are required and locate in valve box.
- B. Use coded and labeled wires for each valve. Provide a numbered tag at each end of a wire at valve, and at controller. The number at each end of wire to be the same.
- C. Provide 48 inches loop in wires at each valve where controls are connected and at 100 foot maximum intervals between. Coil wire around 1/2 inch rebar dowel inside of valve box.

- D. Make electrical joints waterproof using specified connectors. Enclose joints in valve boxes.
- E. Install wire in continuous runs with no splices unless approved.
- F. Show wire routes and approved splice locations on As-Built drawings.

3.14 TRACER WIRE INSTALLATION

- A. Install trace or locate wire under main lines. Trace or locate wire is required in all mainline trenches and in all trenches with control wiring. Locate wire shall be a continuous run; any sections shall be spliced together with watertight splice connectors and locations shown on As-Built Drawings.

3.15 CENTRAL CONTROL COMMUNICATION WIRE INSTALLATION

- A. Install continuous run of communication wire from Flow Sensor to Irrigation Controller. Follow same installation procedures as Control Wire Installation. No splicing of wire is permitted.

3.16 IRRIGATION CONTROLLER INSTALLATION

- A. Install controller in accordance with manufacturer's specifications and applicable codes. Connect to 120V power supply at location shown on drawings and approved by Owner's Representative.

3.17 ISOLATION-FLOW SENSOR RELAY CIRCUIT

- A. Install circuit relay and connect each irrigation controller to circuit per manufacturer instructions. Provide all necessary wiring to master valve and flow sensor.

3.18 MAINLINE PRESSURE TEST AND INSPECTION

- A. Prior to backfilling and installing valves test irrigation mainline for leakage. Establish and maintain 100 psi pressure for 1 hours. Perform test a minimum of 24 hours after set-up of solvent weld. Notify Owner's Representative a minimum of 24 hours for review of pressure gauge at beginning and end of test period. Mainline will be accepted if pressure loss is less than 3 psi.
- B. Before testing, fill pipe with water and expel air from pipes.
- C. Following the pressure test but prior to backfilling, notify Owner's Representative for review of pipe, fittings, joints, thrust blocks, bedding, control wire installation, valves, and other materials for installation and water tightness.
- D. After successful pressure test and mainline inspection begin backfilling and assembly of zones and system components.

- E. Include test documentation in the O & M manual.

3.19 BACKFILLING

- A. Remove debris, sharp rocks, and decayable matter from areas to be back filled before proceeding.
- B. Main Lines: Provide 4 inch Sand cover over piping then place Utility Locate Wire the entire length of pipes where control wires are not present. Backfill remainder of trench with Topsoil or Loam.
- C. Lateral Lines: Backfill trench with Topsoil or Loam. Protect piping from displacement.
- D. At Paved Areas: Backfill trench with Sand under paved areas.
- E. Compact backfill in 6 inch lifts to match density of surrounding material. Install backfill to match adjacent elevations.

3.20 FLUSHING

- A. Mainline: Open valves and thoroughly flush piping system under full water head after piping, risers, and valves are installed. Maintain flushing for three minutes. Close valves and cap risers immediately after flushing.
- B. Second Flushing: Flush a second time after installation of lateral lines and sprinklers prior to nozzle installation. Flush under full water head for three minutes. Install nozzles after flushing.

3.21 SPRINKLER HEAD INSTALLATION

- A. Install plumb with top of Topsoil/Loam or Mulch as detailed and at locations shown on drawings. Allow a maximum of 3 inches clearance between sprinkler head and adjacent lawn or planting edge.
- B. Install 1 cubic foot Pea Gravel sump on all low irrigation heads where drainage occurs at zone shutdown.

3.22 SYSTEM REVIEW

- A. Prepare and start system in accordance with manufacturer's instructions. Prior to notifying Owner's Representative for review of the system review zones and make adjustments to ensure full and even coverage.
- B. Notify Owner's Representative for review of system operation to determine if water afforded to all areas is complete, adequate, and uniform.
- C. Adjust system for full water coverage as directed.

3.23 SYSTEM DEMONSTRATION TO OWNER

- A. Instruct Owner's personnel in operation and maintenance of system, including adjusting of sprinkler heads. Use operation and maintenance data as basis for demonstration.

3.24 CLEANING

- A. Remove excess excavation, backfill materials, and other left over materials from the site. Clean improvements soiled by Work of this Section.

END OF SECTION 328000

SECTION 329000 - PLANTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Soil Material placement.
- B. New trees, plants, ground cover, and lawns.
- C. Mulch and Fertilizer.
- D. Maintenance.

1.2 RELATED REQUIREMENTS

- A. Section 015639 - Temporary Tree and Plant Protection.
- B. Section 328000 - Irrigation.

1.3 DEFINITIONS

- A. Weeds: Any plant life not specified or scheduled. Includes seeds and roots.
- B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1.

1.4 REFERENCE STANDARDS

- A. Quality definitions, grading tolerances, root system condition, caliper height, branching, budding: ANSI/ANLA Z60.1 - American Standard for Nursery Stock, latest edition.
- B. Nomenclature conforms to "Standardized Plant Names," 1942 Edition, published by J. Horace McFarland Co., or "New Sunset Western Garden Book," listed in these references are those used most commonly in the nursery trade.

1.5 PROTECTION

- A. Protect existing improvements and growth in areas to remain undisturbed until completion of project. Leave in similar condition as found.
- B. Maintain benchmarks, monuments, and other reference points. Replace if disturbed or destroyed.

- C. Contact local utility companies for verification of the location of underground utilities within the project area prior to starting excavation. Protect utilities and maintain in continuous operation or in operational condition during work. Repair damage to known utilities or related facilities in an approved manner at Contractor's expense.
- D. Protect drainage inlets and underground drain lines from infiltration or clogging by soils and mulch during construction until Final Completion.
- E. Protect materials of this Section before, during, and after installation. Protect installed work and materials of other trades. In the event of damage immediately make repairs or replacements as directed by BSD Representative.

1.6 SUBMITTALS

- A. Maintenance Data: Include written instructions covering yearly recommended maintenance and care of plantings including fertilization, pest and disease control, weed control, mulching, and pruning.
- B. Quality Assurance Data: Submit license information and project references including name and location of previous projects, date of installation, square footage of areas with planting work, and Owner's contact information.
- C. Submit list of plant life sources within 14 calendar days of Agreement Date.
 - 1. Submit confirmation from supplier(s) that specified plant materials, meeting the specifications, have been secured.
 - 2. Include plant name, quantity, size, condition, and name of supplier.
 - 3. Submit certification letter from the sod supplier(s) stating the sod has been secured or contracted for delivery. Include the quantity, grass mix, and description.
- D. Product Data: Submit manufacturer's printed data for products and a list of suppliers.
- E. Sample: Submit a 2 quart sample of imported Soil Material and Mulch with supplier's name and specific location of source. Approval by Owner's Representative is required prior to delivery to the site.
- F. Submit analysis of Soil Material indicating USDA classification, macro and micro nutrients, organic matter, and recommendations for amendments.
- G. Invoices: Within 2 days of delivery submit invoices, load tickets, and truck measures for Organic Material and Mulch.

1.7 QUALITY ASSURANCE

- A. Valid Oregon Landscape Contractor's license.
- B. Valid Oregon Landscape Business license.
- C. Herbicide applicators must have valid State of Oregon Herbicide Applicator's license.

- D. Installer Qualifications: Company specializing in installing and planting the plants with 10 projects of comparable scale successfully completed.

1. Submit names, addresses, and dates of previous projects, Owners.

1.8 COORDINATION

- A. Coordinate with other trades affecting and affected by Work of this Section.
- B. Pre-Installation Conference: Attend conference to coordinate Work of this Section and other related Sections.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.
- B. Deliver plant life materials immediately prior to placement. Keep plants moist. Protect and maintain plant life until planted.
- C. Deliver products in original unopened packaging with legible manufacturer's identification.
- D. Seed containers shall show manufacturer's guaranteed analysis of seed mixture, percentage of purity, year of production, date and location of packaging, name and trademark, and conformance with governing regulations.
- E. Plants may be rejected if:
1. Ball of earth surrounding roots has been dried out, cracked, or broken.
 2. Burlap, staves, wire baskets, or ropes required in connection with transplanting have been displaced.
 3. Grower or nursery identification labels have been displaced prior to acceptance.

1.10 ENVIRONMENTAL CONDITIONS

- A. Do not install plant life and seed when ambient temperatures is below 32 degrees F or above 90 degrees F, wind speed exceeds 30 mph, or soil becomes saturated.
- B. Install plant materials and seed during periods which are normal for such work as determined by biological season, specified environmental conditions, accepted practice, and after all major construction work has been completed.
- C. Planting Seasons:
1. Seeding: Permitted between April 15 and September 1 unless otherwise approved. Refer to any jurisdictional requirements for seeding and establishment requirements.
 2. Other: Permitted during any period, except when prohibited by other portions of this Section.

1.11 REVIEWS

- A. See Part 3 Execution for review requirements.
- B. Request the following reviews by the Owner's Representative 2 days in advance:
 - 1. Subgrade preparation
 - 2. Soil Material placement
 - 3. Organic Material placement
 - 4. Finish grading
 - 5. Plant materials
 - 6. Plant material layout
 - 7. Planting mock-up
 - 8. Completion
- C. Coordinate all reviews to coincide with regular progress meetings where possible.

1.12 RECORD DOCUMENTS

- A. Produce, keep current, and submit legible record documents on a clean set of plans and details supplied by the Owner's Representative. Use white-out and red ink to legibly re-draft actual locations of installed work.

1.13 WARRANTY

- A. Provide one year warranty following Final Completion or one full growing season following Final Completion, whichever is later.
- B. Replacements: Plants of same size and species as specified, planted in the next growing season, with a new warranty commencing on date of replacement.
- C. Inspection: Visit work at least once a month during warranty period. Notify Owner's Representative and Owner in writing of any observed conditions requiring attention. Failure to provide such notification renders any deficiencies the Contractor's responsibility to rectify.
- D. At the end of the warranty period, as directed by Owner's Representative and at no additional cost to the Owner:
 - 1. Replace work not surviving, in poor condition, or not exhibiting satisfactory growth.
 - 2. Lawns must be healthy, dense, uniform, well sodded, and reasonably weed free as judged by the Owner's Representative
 - 3. Reset plant materials which have settled
 - 4. Replace plant materials which appear to be a different species or variety than specified.
 - 5. Provide noxious weed eradication from imported Soil Material, if required and as specified herein.
 - 6. Complete warranty work within 30 days of warranty review.

- E. Contractor is not responsible for plant loss or damage to work during warranty period which is caused by unusually extreme weather, vandalism, or Owner's lack of maintenance.

PART 2 - PRODUCTS

2.1 PLANTS

- A. Plants: Species and size identified in plant schedule, grown in climatic conditions similar to those in locality of the work.
- B. General:
1. Sizes, grades, and conditions are listed on Plant List. Quantities are shown for Contractor's convenience. Contractor is responsible for providing plants drawn on drawings.
 2. Cold storage stock unacceptable.
 3. Free of disease, decay, injury, insects, or indication of strawberry root weevil.
 4. Full foliated when in leaf.
 5. Furnish balled and burlapped (B&B) stock with solid, properly wrapped and secured, natural ball. Stock 2 inch caliper and up to be transported and handled with root ball in wire basket.
 6. Furnish container stock with sufficient roots to insure healthy growth but not root bound. When plant is removed from container soil must hold together and roots must be visible but not encircling.
 7. Free from Weeds or strawberry root weevil.
 8. Field grown trees and shrubs must have been transplanted or root pruned at least once no more than two years prior to this Contract.
 9. Container stock may be substituted for Balled and Burlapped (B&B) or Bare Root (BR) stock at any time.
- C. Trees shall have:
1. Single, straight, uniformly tapering trunks which are perpendicular to the ground, unless specified as multi-stemmed or otherwise on Plant List. Trees with co-dominant, damaged, crooked, or topped leaders will be rejected.
 2. Healthy and vigorous overall condition.
 3. Full and even branch distribution; structural scaffold branches at least 4 inches apart where they attach to the main trunk.
 4. Well-developed root systems. Trees with more than 2 inches of root ball soil covering root flare will be rejected.
 5. Grafts near ground level.
 6. Minimum/maximum branching heights above the ground unless specified otherwise on Plant List:
 - a. 2.5 inch caliper tree: 6' - 7'
 - b. 2 inch caliper tree: 5' - 7'
 - c. 1.5 inch caliper tree: 4' - 6'

7. Trees shall be free of:
 - a. Major structural defects including, but not limited to, branches with narrow angle of attachment (less than 40 degrees to the trunk), bark with major branch unions, and trees with co-dominant leaders.
 - b. Poor pruning practices including, but not limited to, stubbed branches and topped leader.
 - c. Damage to the trunk, branches, and root system including, but not limited to, bark abrasions, sun scald, and disfiguring knots.
8. Trees shall be freshly dug during the most recent favorable harvest season.

2.2 SOIL MATERIALS

- A. Planting Soil:
 1. Topsoil: On-site soil, natural, fertile, friable; free of rock, clay, subsoil, clods, lumps, plants, roots, sticks, weeds, seeds, and other deleterious material larger than 3/4", as approved.
 2. Loam: Imported, natural, fertile, friable; free of rock, clay, subsoil, clods, plants, roots, sticks, weeds, seeds, and other deleterious material. Shall conform to USDA soil texture class "loam".
- B. For soil in storm water planters refer to Civil specifications.
- C. Source Quality Control: Submit analysis of Soil material indicating source of material, USDA classification, macro and micro nutrients, organic matter, and recommendations for amendments.

2.3 SOIL AMENDMENT MATERIALS

- A. Lawn Installation Fertilizer: Uniform composition, dry, and free flowing of proportion necessary to eliminate any deficiencies of topsoil, as recommended by the Soil Testing Agency.
- B. Lawn Maintenance Fertilizer: Uniform composition, dry, and free flowing of proportion necessary to eliminate any deficiencies of topsoil, as recommended by the Soil Testing Agency.
- C. Plant Bed Maintenance Fertilizer: Uniform composition, dry, and free flowing of proportion necessary to eliminate any deficiencies of topsoil, as recommended by the Soil Testing Agency.
- D. Planting Tablets: Sierra Chemical "Agriform" with 20-10-5 chemical analysis, or approved equal.
- E. Micorrhizal Fungi: MycroApply® All Purpose Granular by Micorrhizal Applications Inc, Grants Pass, Oregon (541-476-3985), or approved equal.
- F. Water: Clean, fresh, and free of substances or matter that could inhibit vigorous growth of plants.

- G. Organic Material: 100% organic garden compost materials following guidelines and tested to meet the US Composting Council's seal of testing assurance.

- H. Biological Amendments:

1. Soil ProVide by Earthfort, Corvallis, Oregon, or approved.
2. Soil ReVive by Earthfort, Corvallis, Oregon, or approved.

2.4 RIVER ROCK TRENCH

- A. River Rock of

Large	10-12 inches
Medium	8-10 inches
Small	6-8 inches

2.5 GRASS SEED

- A. Certified Oregon Blue Tag Free of Weed seed with dealer's statement analysis guarantee.

- B. Current or latest season's crop labeled in conformance with State and US Department of Agriculture laws and regulations:

1. Purity: 98% by weight
2. Germination: 90%

- C. Products:

1. Seed at Lawns:
 - a. Rye grass fescue mix. Annual rye is not to be included in seed mix.
 - b. Rate: 10 pounds per 1,000 square feet.

2.6 MULCH MATERIALS

- A. Bark Mulch at Plant Beds: Hemlock species wood shavings, free of growth or weeds, "sliver free".

2.7 ACCESSORIES

- A. Wrapping Materials: Burlap.
- B. Stakes: 2 x 2 inch x 8 feet wood stakes, capable of at least 2 years ground burial, stained charcoal or black.
- C. Tree Ties: Chain lock tree ties, 1 inch wide, or approved.

- D. Root Deflectors: Extruded polyethylene panels, 18 inches deep, each having at least 4 molded root deflecting ribs at a maximum of 6 inches on center running from top to bottom of each panel; Panels are connected by means of integral male/female sliding locks.

- 1. RS-18 by Root Solutions, San Rafael, CA; (800) 554-0914, or approved equal.

2.8 HERBICIDE

- A. Broad Spectrum Non-Selective: Buccaneer Plus, or approved equal.
- B. Selective for Broadleaves: Speed Zone, Weed-B-Gone, or approved equal.
- C. Selective for Grasses: Envoy or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to installation of Work of this Section, carefully inspect the work of others and verify that such work is complete to the point where this installation may properly commence.
- B. Verify that materials and surfaces to receive work specified herein are accurately sized, shaped, and located; sound, secure, true, complete, and otherwise properly prepared.
- C. Verify subgrades produce positive drainage and allow for placement of Soil Material, Amendments, and Mulch to specified depths.
- D. Do not install Work of this Section until all unsatisfactory conditions have been corrected. Beginning Work of this Section signifies acceptance of existing conditions.

3.2 TOLERANCES

- A. Perform earthwork true to lines and grades, and to prevent ponding of water, with maximum variation in elevations of +/- 1/2 inch at subgrades and +/- 1/4 inch at finish grades.
- B. Compacted thickness of materials within 1/4 inch of specified thickness.

3.3 SOIL TESTING

- A. Submit samples of Soil Material to testing agency.
- B. Provide planting plan to testing agency along with soil samples.
- C. Soil Testing to include the following:
 - 1. Chemical Soil Analysis (Macro and micro nutrients)

2. USDA Soil Classification.
3. Organic matter content.

- D. Provide test results and recommendations for amendments to Owner's Representative.
- E. Note to Bidders: The cost for products related to biological and fertilizer amendments will be a change to the contract. The labor for incorporating amendments shall be included in the bid based on descriptions in Part 3.

3.4 PREPARATION OF SUBGRADE

- A. Prepare subsoil to eliminate uneven areas or low spots. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
- B. Remove foreign materials, weeds and undesirable plants and their roots, stones, rock, and dirt clods. Remove contaminated subsoil.
- C. Scarify subsoil to a depth of 6 inches where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.
- D. Verify subgrades, whether comprised of subgrade soil or fill drain freely. Test area by flooding with Owner's Representative present. Where water does not drain freely auger a 10 inch hole, minimum 1 per 1,000 square feet, through fill material and into subsoil, or minimum 4 feet deep into subsoil to establish positive drainage.
- E. Verify subgrades allow for placement of Soil Material, Amendments, and Mulch to depths specified.
- F. Notify Owner's Representative for Subgrade Preparation Review prior to placing Soil Material.

3.5 PLACING SOIL MATERIAL

- A. Soil Placement Schedule:
1. At Plant Beds: 18 inches minimum depth.
 2. At Lawns: 6 inches minimum depth.
 3. Place additional Soil Material as required to establish finish grades shown on drawings and to fill in depressions, blend grades, and produce positive drainage.
- B. Place Soil Material during dry weather and on dry unfrozen subgrade. Suspend Soil Material placement if subgrade or Soil Material become saturated.
- C. Phase Soil Material placement so that equipment does not travel over Soil Material already installed.
- D. Place Soil Material in a relatively dry state to depths specified at locations shown on Drawings:
1. Remove stones, roots, grass, weeds, debris, and foreign material while spreading.
 2. Manually spread around existing trees, paving, and other structures to prevent damage.

3. Establish levels, profiles, slopes, contours, and uniform gradients between given grade points as shown on Drawings.
4. Eliminate uneven or low spots at lawns and plant beds.
5. Fine grade Soil Material within specified tolerances.

- E. Notify Owner's Representative for Soil Material Placement Review prior to proceeding with Work.

3.6 ROOT DEFLECTOR INSTALLATION

- A. Install 10 foot lengths of Root Deflector at all curbs and paving which are within 5 feet of new trees as noted and detailed on drawings.
- B. Install Root Deflector to a minimum of 18 inches deep.

3.7 INITIAL WEED CONTROL

- A. Inspect plant beds, lawns, and meadows for the presence of weeds. If weeds are present apply broad spectrum herbicide.
- B. During herbicide application ensure safety and environmental precautions are taken and best management practices are employed. Adjust procedures adjacent to waterways.

3.8 SOIL PREPARATION AND FINISH GRADING

- A. Remove debris, sticks, roots, clods, stones, and soils contaminated by petroleum products at plant beds and lawns. Rake smooth, eliminate uneven areas or low spots in Soil Material, and set grades for positive drainage.
- B. At plant beds:
 1. Apply herbicide to remove weeds as described in Initial Weed Control.
 2. Spread fertilizer over the plant bed as recommended by the Soil Material test results.
 3. Spread 3 inches Organic Material over entire plant bed. Organic Material must be incorporated immediately into plant beds, no stock piling is permitted.
 4. Notify Owner's Representative for Organic Material Placement Review prior to proceeding with tilling and planting.
 5. Thoroughly rototill Organic Material and amendments into the top 6 inches of Soil Material, except within Tree Protection fencing where plants will be pocket planted.
 6. Rake smooth and reset finish grades eliminating uneven or low spots in plant beds and setting grades for positive drainage. Ensure grades at edges of plant beds allow for placement of Mulch Material to specified depths and as detailed.
 7. Spread biological amendments.
- C. At trees:
 1. Thoroughly mix 5 parts Soil Material and 1 part Organic Material for backfilling trees.

D. At lawns:

1. Apply herbicide to remove weeds as described in Initial Weed Control.
2. Spread fertilizer as recommended by the Soil Material test results.
3. Rototill to a minimum depth of 4 inches, except within Tree Protection fencing.
4. Set finish grades to ensure that finish grade of lawn will be flush with surrounding surfaces.
5. Establish a friable, fine textured seed bed free of bumps and depressions immediately before seeding.
6. Firm seed bed with a lawn roller making passes in 2 directions.
7. Spread biological amendments.

E. At lawn repair areas:

1. Manually remove weeds as described in Initial Weed Control.
2. Place additional Soil Material as necessary to fill in depressions and blend grades with surrounding lawns, plant beds, and paving.
3. Set finish grades to ensure that finish grade of lawn will be flush with surrounding surfaces.
4. Establish a friable, fine textured seed bed free of bumps and depressions immediately before seeding.
5. Firm seed bed with a lawn roller making passes in 2 directions.
6. Spread Lawn Installation Fertilizer at the rate of 15 lbs. per 1000 square feet. If a Terraseeding method is used for lawn installation do not apply Lawn Installation Fertilizer.

F. Notify Owner's Representative for Finish Grading Review prior to proceeding with Work.

3.9 RIVER ROCK PLACEMENT

A. Install River Rocks after Accent Stones are in place.

B. River Rock mock-up:

1. Install approximately 100 square foot section showing typical condition for review.
2. Notify Owner's Representative for mock-up review.

C. Large and Medium River Rock:

1. Scatter in a random fashion over remaining areas where rock is shown to be installed.
2. Adjust rocks into horizontal positions, not vertical. Tamp into place.
3. Notify Owner's Representative of progress and allow to make adjustments.

D. Small River Rock:

1. Cover area where rock is shown to be installed. Tamp into place.

3.10 SECOND WEED CONTROL

- A. After completion of Soil Preparation and finish grading commence irrigation of all plant beds and lawns. If weeds are present apply broad spectrum herbicide.
- B. Wait ten days minimum and inspect all plant beds and lawn areas for the presence of any additional weeds. If weeds are present, apply a second application of Herbicide to affected areas and delay planting until all weeds are dead.
- C. During herbicide application ensure safety and environmental precautions are taken and best management practices are employed. Adjust procedures adjacent to waterways.

3.11 INSTALLATION OF PLANT MATERIAL

- A. Plant Material Review: Notify Owner's Representative prior to the delivery of all trees and plant materials to the site but prior to installing plants. Owner's Representative will review quality of plant materials and reject plant materials not in compliance the Plant List and Specifications. This review is preliminary. Final approval of plants materials will not be given until Completion Review.
- B. Plant Material Layout Review: Layout plant material (in containers or B&B) at plant beds for review prior to installation. Notify Owner's Representative for review of plant material layout prior to commencement of planting. The plant material layout review may occur concurrently with the planting mock-up review. Adjust plant materials as directed.
- C. Planting Mock-Up Review: Notify Owner's Representative prior to commencement of planting. Install an initial 1000 square feet sample of typical plantings for review. Adjust planting procedure as directed.
- D. Tree Planting:
 - 1. Soak container grown, B&B, and BR plants before planting.
 - 2. Remove extra soil on top of root ball to expose flare of first buttress root. Root flare must be visible at top of root ball.
 - 3. Dig individual planting holes circular with vertical sides as shown on Planting Detail.
 - 4. Save and thoroughly loosen soil removed from planting hole and use as backfill around tree. Backfill trees with specified mixture if additional Soil Material is needed.
 - 5. Sprinkle micorrhizal fungi to surface of planting holes at rate of 2-4 ounces per inch of stem caliper.
 - 6. Lift trees by wire basket only. Do not lift trees by trunk or use trunk as a lever to position or move tree.
 - 7. Set B&B trees in the hole with the north marker facing north unless otherwise approved.
 - 8. Set root crown as shown on Planting Detail not less than 3 inches above surrounding finish grade.
 - 9. Cut and completely remove twine and other fasteners from root ball. Remove burlap from top half of root ball. Remove all burlap if not biodegradable. Neatly cut off broken or frayed roots.
 - 10. Remove top half of wire basket after planting.
 - 11. Stake trees as shown on Planting Detail.

E. All other Plants:

1. Soak container grown, B&B, and BR plants before planting.
2. Dig individual planting holes with circular and with vertical sides 1-1/2 inch shallower than depth of root ball.
3. Dig holes for pocket-planted shrubs 3 times the diameter of the rootball.
4. Sprinkle micorrhizal fungi to surface of planting holes at the following rates:
 - a. #SP4 container - 1 tablespoon
 - b. #1 container - 2 tablespoons
 - c. #3 container - 3 tablespoons
 - d. #5 container - 5 tablespoons
5. Install Planting Tablet at shrubs and ground covers at manufacturer's recommended high rate.
6. Cut circling roots with a sharp knife.
7. Set root crowns 1-1/2 inch above surrounding grade and as detailed.

F. Plants set too deeply will be rejected. Reset plants that have settled.

G. Set Plants plumb and for best appearance.

H. Carefully tamp soil under and around root balls and bare roots to prevent settlement.

I. Backfill pocket-planted plants with equal parts Soil Material and Organic Material.

J. Flood hole when half backfilled and tamp soil between bare roots.

K. Complete backfilling and tamp soil between bare roots.

L. Thoroughly water each plant and entire bed immediately after planting.

M. Remove all tags, labels, strings, etc. from plants.

N. Prune Plant Material to remove dead, broken, or damaged branches.

O. Rake plant beds smooth, resetting finish grades for positive drainage and eliminating uneven or low spots.

3.12 BIOLOGICAL AMENDMENT INSTALLATION

- A. Water apply biological amendments per manufacturer's recommended high rate at plant beds and lawns.

3.13 MULCH INSTALLATION

- A. Install 3 inch minimum depth Mulch within 24 hours after planting at plant beds and trees as shown on drawings and details.

- B. Remove excess Mulch from foliage of plant materials and from bark of trees. Mulch must not be placed within 3 inches of tree trunks. Remove mulch from adjacent surfaces and produce edges shown on Details.

3.14 LAWN INSTALLATION

- A. Install lawns using one of the following methods:
 - 1. Hydroseeding:
 - a. Mix seed at required rate, fertilizer, and biological amendments with sufficient hydromulch to keep areas moist during germination and protect seed from wind erosion.
 - b. Ensure all equipment, including hoses, is clean and contains only the specified seed.
- B. Apply water with fine spray immediately after each area is sown.
- C. Provide a temporary barrier at the limits of newly planted lawns.

3.15 MAINTENANCE

- A. At Plant Beds during period between installation and Final Completion:
 - 1. Water, fertilize, weed, reset unstable or disturbed plants, and perform other maintenance necessary to assure healthy growth.
 - 2. Install Plant Bed Maintenance Fertilizer as recommended by Soil Testing Agency 45-60 days after installation. Adjust timing for seasonal requirements of plant materials.
 - 3. Thoroughly water immediately after applying Plant Bed Maintenance Fertilizer.
 - 4. Repair and regrade erosion damage .
 - 5. Provide continued weed control and removal until any weed problem is fully eradicated.
- B. At lawns during period between installation and Final Completion:
 - 1. Water, weed, mow, reseed, top dress, and fertilize as necessary to establish a healthy, dense, uniform, weed free stand of grass; maintain at 2 inches high. This includes unirrigated lawns, unless otherwise noted on drawings.
 - 2. Conduct first mowing after grass is firmly rooted and secure. Mow grass when it exceeds 2 inches in height, cutting no more than 1/3 of the grass height at a time. Remove all clippings.
 - 3. Maintain surfaces and supply additional Soil Material and Seed where necessary.
 - 4. After first mowing apply Lawn Maintenance Fertilizer as recommended by Soil Testing agency. Thoroughly water after application.
 - 5. Apply Herbicide (selective) to remove weeds.

3.16 MAINTENANCE AFTER FINAL COMPLETION

- A. Provide maintenance of landscape, plantings, and lawns for a minimum of one year after Final Completion. Replace plants that have failed or are in decline at the end of the one year period.

3.17 CLEANING

- A. Remove excess materials from site. Protect drain inlets and underground piping as necessary and clean improvements soiled by Work of this Section.

3.18 COMPLETION REVIEW

- A. Notify Owner's Representative for Completion Review when Work of this Section is complete.

END OF SECTION 329000

SECTION 331100 – WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for water line distribution piping.

1. Pipe and fittings for potable water line and fire water line.
2. Valves and Valve Boxes.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
1. Section 312317 Trenching
 2. Section 331200 Water Distribution Equipment
- C. City of Beaverton Engineering Design Manual and Standard Drawings.
- D. AWWA – American Water Works Association.

1.3 SUBMITTALS

- A. Section 013300 – Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data on pipe materials, pipe fittings, valves, and accessories.
- C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.
- D. Project Record Documents: Record as-constructed locations of piping mains, valves, connections, thrust restraints, and invert elevations.
- E. Identify and describe unexpected variations to subsoil conditions or discovers of uncharted utilities.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with City of Beaverton Engineering Design Manual and Standard Drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers with manufacturer's name and pressure rating labeling in place.
- B. Store pipe and pipe materials in designated areas on-site.
- C. Store polyethylene materials out of sunlight.

PART 2 - PRODUCTS

2.1 WATER PIPING

- A. Public Water mains 6" and larger.
 - 1. Push-on joint Ductile Iron Pipe, Class 52, cement-mortar lined conforming to ANSI/AWWA C151/A 21.51 and ANSI A21.11. Rubber ring gaskets shall conform to ANSI A21.11, suitable for the specified pipe sizes and pressures. Fitting joints shall be mechanical joint ends.
- B. Private water lines 4" and larger
 - 1. Push-on joint Ductile Iron Pipe, Class 52, cement-mortar lined conforming to ANSI/AWWA C151/A 21.51 and ANSI A21.11. Rubber ring gaskets shall conform to ANSI A21.11, suitable for the specified pipe sizes and pressures. Fitting joints shall be mechanical joint ends.
 - 2. PVC AWWA C-900 and AWWA C905, designated for potable water use. Class DR 18, 150 psi, and DR 14, 200 psi.
- C. Private water lines 2" and smaller
 - 1. PVC Schedule 40 designated for potable water use.
 - 2. Copper pipe type K.

2.2 FITTINGS

- A. Ductile Iron Fittings shall conform to ANSI / AWWA C110 / A21.10 and/or ANSI / AWWA C153/ A 21.53. Fitting joints shall have mechanical joint (MJ) ends.
- B. Mechanical Joint Fittings and Restraints
 - 1. Mechanical joint fittings shall be ductile iron short pattern.
 - 2. Fittings shall conform to ANSI / AWWA C110 / A21.10 and shall be of a class at least equal to that of the adjacent pipe.
 - 3. Bolts shall be domestic Cor-Ten or ductile iron tee-head bolts.
 - 4. Mechanical Joint Restraints.

- a. The restraint shall be MEGALUG Series 1100 restraint device as manufactured by EBAA Iron, Inc.

C. Flanged Fittings

1. Flanged fittings shall conform to ANSI / AWWA C110/A21.10 and shall be faces and drilled Class 124 flanges that match ANSI B16.1 fittings.
2. Flanged fittings shall be ductile iron.
3. Flange bolts and nuts shall be Grade 304 or 316 stainless steel with standard course threads. Threads on bolts and nuts shall be coated with a food grade anti-seize material to prevent thread galling.

D. Gaskets

1. Gasket material for flanged joints in ductile iron pipe shall consist of 1/8-inch thick, full-face one-piece, cloth inserted, rubber gaskets conforming to section 4 of ANSI/ AWWA C207 and ANSI B16.21.

E. Restrained Joints

1. Joints shall be restrained using either mechanical joint restraints or Field Lok™ (Tyton), Fastite™ (American) gaskets.
2. Thrust block and straddle block materials shall be 3,500 psi minimum compressive strength concrete.

F. Tapping Sleeves

1. Conforming to City of Beaverton Design Manual.

2.3 VALVES and VALVE BOXES

- A. Gate Valves – conforming to City of Beaverton Design Manual.
- B. Valve box and cover – conforming to City of Beaverton Standard Drawing No. 615.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Verify existing utility water main size, location, and inverts are as indicated on the Drawings.

3.2 EXCAVATION

- A. Excavate pipe trench in accordance with Section 312317 Trenching. Hand trim excavation for accurate placement of pipe to elevations indicated on Drawings.

3.3 INSTALLATION

- A. Install ductile iron pipe and fittings in accordance with AWWA C600 and manufacturer's instructions.
- B. Install PVC pipe in accordance with AWWA C605 and manufacturer's instructions.
- C. Install water pipe in conformance with the City of Beaverton Design Manual.

3.4 DISINFECTION AND TESTING

- A. Disinfection and testing shall be in conformance with the City of Beaverton Design Manual.

END OF SECTION 331100

SECTION 331200 – WATER DISTRIBUTION EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

- A. This sections specifies requirements for water appurtenances.
 - 1. Appurtenances commonly used for potable water line and fire water line.
 - 2. Valves and Valve Boxes, Fire Hydrants

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Related Sections
 - 1. Section 312317 Trenching
 - 2. Section 331100 Water Distribution Piping
- C. City of Beaverton Engineering Design Manual and Standard Drawings.
- D. AWWA – American Water Works Association.

1.3 SUBMITTALS

- A. Section 013300 – Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit data on pipe materials, pipe fittings, valves, and accessories.
- C. Manufacturer’s Certificate: Certify products meet or exceed specified requirements.
- D. Project Record Documents: Record as-constructed locations of piping mains, valves, connections, thrust restraints, and invert elevations.
- E. Identify and describe unexpected variations to subsoil conditions or discoveries of uncharted utilities.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with City of Beaverton Engineering Design Manual and Standard Drawings.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store valves in shipping containers with manufacturer's name and pressure rating labeling in place.
- B. Store pipe and pipe materials in designated areas on-site.
- C. Store polyethylene materials out of sunlight.

PART 2 - PRODUCTS

2.1 FIRE HYDRANTS

- A. Fire hydrants shall conform to AWWA C502 and shall be complete with all necessary fittings and accessories. Fire hydrants shall be equipped with to 1-1/2 inch hose outlet nozzles and one 4-1/2 inch pumper outlet nozzle with threads conforming to NFPA 194 for National Standard Fire Hose Coupling Screw Threads. Minimum hydrant valve opening shall be 5-1/4 inches. The minimum hydrant branch lines shall be 6-inches. The inlet connection to the base of the hydrants shall be 6-inches with end type as shown on the drawings or specified elsewhere in the specifications. The hydrant shall open left (counterclockwise) and be of sufficient length for 5 foot burial. Hydrants shall be of the "break away" type to minimize breakage of hydrant parts in case of damage. The 4-1/2 inch port shall have a Storz quick adaptor.
- B. Manufacturers:
 - 1. Mueller, 3-way, 5-1/4 inch Super Centurion 200
 - 2. Clow Medallion F-2545
 - 3. Kennedy Guardian K-81D
 - 4. Waterous Pacer WB67-250
 - 5. M&H Regent Style 129

2.2 GATE VALVES, BOX, AND COVER

- A. Gate valves, boxes, and covers shall conform to the City of Beaverton Standards.
- B. Valves eight (8) inches and smaller shall be gate valves. Only resilient wedge gate valves shall be installed.
- C. Valves must meet AWWA C509 Standard for Resilient Seated Gate Valves.
- D. Valve body and bonnet shall be epoxy coated inside and out with fusion bonded epoxy. Coating shall conform to AWWA C550 Standard Protective Coatings for Valves and Hydrants.

2.3 BUTTERFLY VALVES, BOX, AND COVER

- A. Butterfly valves, boxes, and covers shall conform to the City of Beaverton Standards.

- B. Valves ten (10) inches and greater shall be butterfly valves.
- C. All butterfly valves installed shall conform to AWWA C504 Standard for Rubber Seated Butterfly Valves.

2.4 BLOWOFF ASSEMBLY

- A. Blowoff size must be in accordance with AWWA flushing flow rates, but not less than 2 inches for 8 inch lines and smaller, and 4 inches for lines larger than 8 inches.

2.5 COMBINATION AIR AND VACUUM RELEASE VALVE

- A. Combination Air and Vacuum Release Valve shall be installed at dead ends where there is a risk of a vacuum being created due to water shut down.
- B. Combination Air and Vacuum Release Valve shall be installed at high points in the water system.

2.6 WATER METER, BOXES, AND VAULTS

- A. Water meter and Water meter boxes/vaults shall conform to the City of Beaverton Standards.

2.7 BACKFLOW DEVICES AND VAULTS

- A. Backflow prevention assemblies shall conform to the City of Beaverton Standards.
- B. Backflow prevention assemblies shall be installed on the Domestic water service, Fire water service, and the irrigation service.
- C. Fire service backflow prevention assemblies shall be installed at the edge of the public water line easement.
- D. Only approved Double Detector Check Valve Assemblies are to be used for system containment on fire line services.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. General:
 - 1. Install water appurtenances as shown, specified, as recommended by the manufacturer, and as required by the City of Beaverton Design Manual.
 - 2. In the event of conflict between manufacturer's recommendations and the Contract Documents, request interpretation from Engineer before proceeding.

3. Install service connections and valves where indicated on the plans.

3.2 DISINFECTION AND TESTING

- A. Disinfection and testing shall be in conformance with the City of Beaverton Design Manual.

END OF SECTION 331200

SECTION 333100 – SANITARY SEWER PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for sanitary sewer pipe for a gravity flow sewerage system.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this Section.
- B. Applicable sections of the current Oregon Plumbing Specialty Code, City of Beaverton Design Manual and Standard Drawings, and the Clean Water Services Design and Construction Standards.
- C. All work shall be done in accordance with these specifications and in conformity with the plans.
- D. Related Section
 - 1. Section 312317 Trenching
 - 2. Section 333900 Sanitary Sewer Structures

1.3 SUBMITTALS

- A. Product Data.

1.4 DELIVERY, STORAGE AND HANDLING

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

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other marking or specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastic Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer for plastic sewer piping.

1.6 PROJECT CONDITIONS

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

PART 2 - PRODUCTS

2.1 PUBLIC SANITARY SEWER PIPE

- A. Public Sanitary Sewer Pipe shall conform to City of Beaverton and Clean Water Services Standards.

2.2 SANITARY SEWER PIPING 4" AND LARGER WITH GREATER THAN 3 FEET OF COVER, BEYOND 5 FEET FROM THE BUILDING

- A. PVC Pipe and Fittings
 - 1. Pipe: Shall conform to the requirements of ASTM D3034, SDR 35
 - 2. Fittings: All fitting shall be of the same materials as the pipe unless otherwise approved. Conform to the requirements of ASTM D3034, PVC
 - 3. Gaskets: Shall conform to the requirements of ASTM F 477, elastomeric seals and ASTM 3212
- B. PE Pipe and Fittings
 - 1. Corrugated PE Pipe and Fittings Pipe: Shall conform to the requirements of ASTM D3350
- C. HDPE Pipe and Fittings
 - 1. All HDPE Pipe and Fittings shall conform to the requirements of ASTM F714, DR 26

2.3 SANITARY SEWER PIPING 4" AND LARGER WITH 3 FEET OR LESS OF COVER, BEYOND 5 FEET FROM THE BUILDING

- A. Ductile Iron, Gravity Sewer Pipe and Fittings
 - 1. Pipe: AWWA C150-1, cement lined push-on joint. Class 50.
 - 2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
 - 3. Compact Fittings: AWWA C153, ductile iron, for push-on joints.
 - 4. Gaskets: AWWA C111, rubber

2.4 SANITARY SEWER PIPING WITHIN 5 FEET OF THE BUILDING

- A. PVC DWV, Solid-Wall PVC Pipe shall conform to the requirements of ASTM D 2665, and plumbing code requirements

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in section 312317 Trenching.

3.2 PIPING INSTALLATION

- A. General location and arrangements: Drawing plans and details indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install pipe 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 instruction for using lubricants, cements, and other installation requirements.
- C. 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 complete. Place plug in end of incomplete piping at end of day and when work stops.

3.3 CONNECTIONS

- A. Pothe prior to construction to verify location, size, and depth of existing piping. Notify Engineer if location, size, or depth of existing pipe is different than shown on the plans.

3.4 FIELD QUALITY CONTROL

- A. Inspection and testing shall be per City of Beaverton and Clean Water Services Standards.

3.5 CLEANING

- A. Clean dirt and superfluous material from interior of piping prior to testing.

3.6 TESTING AND ACCEPTANCE

- A. Testing shall be in conformance with City of Beaverton Standards, Clean Water Services Standards, and Oregon Plumbing Specialty Code.

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BEAVERTON, OREGON

DLR GROUP PROJECT NO. 74-18109-00

BID AND PERMIT SET

END OF SECTION 333100

SECTION 333900 – SANITARY SEWER STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for sanitary sewer structures for a gravity flow sewerage system.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this Section.
- B. Applicable sections of the current Oregon Plumbing Specialty Code, City of Beaverton Design Manual and Standard Drawings, and the Clean Water Services Design and Construction Standards.
- C. All work shall be done in accordance with these specifications and in conformity with the plans.
- D. Related Section
 - 1. Section 312317 Trenching
 - 2. Section 333100 Sanitary Sewer Piping

1.3 SUBMITTALS

- A. Product Data.
- B. Shop Drawings for Manholes

1.4 DELIVERY, STORAGE AND HANDLING

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

1.5 QUALITY ASSURANCE

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

- B. Comply with NSF/ANSI 14, "Plastic Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

1.6 PROJECT CONDITIONS

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

PART 2 - PRODUCTS

2.1 Polyvinyl Chloride Pipe (PVC)

- A. Pipe and Fittings 4 inches to 15 inches shall be PVC SDR 35, conforming to ASTM D3034.
- B. Joints: PVC pipe shall have integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. Elastomeric gaskets shall conform to ASTM D3212.

2.2 Manholes

- A. Manhole components shall conform to Clean Water Services and the City of Beaverton standards.
- B. All steps within structures must comply with OSHA standards for fixed metal, individual rung ladders (OAR 437), and CWS, except that there shall be no more than 24 inches between the top of the casting and the rung of the top step.
- C. All precast manhole riser sections shall conform to the requirements of ASTM C478.
- D. All poured in place concrete shall have a 28 day strength of 3000 psi, and a slump of 2 inches to 4 inches.
- E. All joints shall be sealed with preformed gaskets such as Kent-Deal #2, Ram-Neck, or an approved equal conforming to federal specifications SS-S00210.
- F. All pipe connections to manhole shall be water tight.
- G. Watertight / tamper proof manhole frame and cover shall be used in all easement and off-street areas.

2.3 Cleanouts

- A. Cleanout components shall conform to City of Beaverton standards.
- B. Cleanout stand pipe shall be the same material and size as the mainline up to and including 8 inch pipe. Mainline greater than 8 inches shall have an 8 inch standpipe.
- C. Cleanout frame and cover shall have a concrete collar.
- D. Cleanout shall have a gas- and watertight threaded plug in conformance with Plumbing Code.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in section 312317 Trenching.

3.2 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C891, City of Beaverton and Clean Water Services Standards.

3.3 CLEANOUT INSTALLATION

- A. General: Install cleanout complete with appurtenances and accessories indicated, and in conformance with Oregon Plumbing Specialty Code, City of Beaverton Standards, and Clean Water Services Standards.
- B. Install cleanouts where indicated on the drawings and per Oregon Plumbing Specialty Code.

3.4 CONNECTIONS

- A. Pothole prior to construction to verify location, size, and depth of existing piping. Notify Engineer if location, size, or depth of existing pipe is different than shown on the plans.

3.5 FIELD QUALITY CONTROL

- A. Inspection shall be per City of Beaverton and Clean Water Services Standards.

3.6 CLEANING

- A. Clean dirt and superfluous material from interior of piping prior to testing.

3.7 TESTING AND ACCEPTANCE

- A. Testing shall be in conformance with City of Beaverton Standards, Clean Water Services Standards, and Oregon Plumbing Specialty Code.

END OF SECTION 333900

SECTION 334100 – STORM DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for storm drainage pipe for a gravity flow storm drainage system.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this Section.
- B. Applicable sections of the current Oregon Plumbing Specialty Code, City of Beaverton Standards, and the Clean Water Services Design and Construction Standards.
- C. All work shall be done in accordance with these specifications and in conformity with the plans.
- D. Related Section
 - 1. Section 312317 Trenching
 - 2. Section 334400 Storm Drainage Inlets
 - 3. Section 334900 Storm Drainage Structures

1.3 SUBMITTALS

- A. Product Data.

1.4 DELIVERY, STORAGE AND HANDLING

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

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other marking or specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastic Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer for plastic sewer piping.

1.6 PROJECT CONDITIONS

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

PART 2 - PRODUCTS

2.1 STORM DRAINAGE PIPING 4" AND LARGER WITH GREATER THAN 3 FEET OF COVER, BEYOND 5 FEET FROM THE BUILDING

A. PVC Pipe and Fittings

1. Pipe: Shall conform to the requirements of ASTM D3034, SDR 35
2. Fittings: All fitting shall be of the same materials as the pipe unless otherwise approved. Conform to the requirements of ASTM D3034, PVC
3. Gaskets: Shall conform to the requirements of ASTM F 477, elastomeric seals and ASTM 3212

B. PE Pipe and Fittings

1. Corrugated PE Pipe and Fittings Pipe: Shall conform to the requirements of ASTM D3350

C. HDPE Pipe and Fittings

1. All HDPE Pipe and Fittings shall conform to the requirements of ASTM F714, DR 26

2.2 STORM DRAINAGE PIPING 4" AND LARGER WITH 3 FEET OR LESS OF COVER, BEYOND 5 FEET FROM THE BUILDING

A. Ductile Iron, Gravity Sewer Pipe and Fittings

1. Pipe: AWWA C150-1, cement lined push-on joint. Class 50.
2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
3. Compact Fittings: AWWA C153, ductile iron, for push-on joints.
4. Gaskets: AWWA C111, rubber

2.3 STORM DRAINAGE PIPING WITHIN 5 FEET OF THE BUILDING

A. PVC Pipe and Fittings

1. PVC DWV, Solid-Wall PVC Pipe shall conform to the requirements of ASTM D 2665, and plumbing code requirements

2.4 PERFORATED PIPE

- A. Rigid round perforated PVC pipe shall conform to the requirements of ASTM D3034, SDR 35.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in section 312317 Trenching.

3.2 PIPING INSTALLATION

- A. General location 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 pipe 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 instruction for using lubricants, cements, and other installation requirements.
- C. 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 complete. Place plug in end of incomplete piping at end of day and when work stops.

3.3 CLEANOUT

- A. Install cleanout where indicated on the plans. Set rim to finish grade.

3.4 CONNECTIONS

- A. Pothe prior to construction to verify location, size, and depth of existing piping. Notify Engineer if location, size, or depth of existing pipe is different than shown on the plans.

3.5 FIELD QUALITY CONTROL

- A. Inspection and testing shall be per City of Beaverton and Clean Water Services Standards.

3.6 CLEANING

- A. Clean dirt and superfluous material from interior of piping prior to testing.

END OF SECTION 334100

SECTION 334400 – STORM DRAINAGE INLETS

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for storm drainage catch basins, area drains, ditch inlets, and atrium inlets for a gravity flow drainage system.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this Section.
- B. Applicable sections of the current Oregon Plumbing Specialty Code, City of Beaverton Design Manual and Standard Drawings, and Clean Water Services Design and Construction Standards.
- C. All work shall be done in accordance with these specifications and in conformity with the plans
- D. Section 334100 Storm Drainage Piping.

1.3 SUBMITTALS

- A. Product Data.
- B. Shop Drawings for inlet, frame, and grate.

1.4 DELIVERY, STORAGE AND HANDLING

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

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other marking or specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastic Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer for plastic sewer piping.

1.6 PROJECT CONDITIONS

- A. Interruption of Utility Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of storm drainage service.

PART 2 - PRODUCTS

2.1 CATCH BASIN – TRAPPED OUTLET

- A. All private trapped catch basins shall have a trapped outlet and minimum 18 inch sump.
- B. Grate dimensions shall be 24 inch by 24 inch square.
- C. Catch basin, frame, and grate shall be H-20 heavy truck traffic rated in vehicle areas.

2.2 CATCH BASIN – STEEL

- A. All private steel catch basins shall have a trapped outlet and minimum 12 inch sump.
- B. Grate dimensions shall be 16 inch by 16 inch square.
- C. Steel catch basins located in pedestrian areas shall have an ADA compliant grate.
- D. Catch basin, frame, and grate shall be H-20 heavy truck traffic rated in vehicle areas.

2.3 LANDSCAPE AREA DRAINS

- A. All private area drains shall have a trapped outlet and a minimum 12 inch sump.
- B. Grate shall be flat or atrium style. See contract plans.

2.4 TRENCH DRAINS

- A. Trench drains located in pedestrian areas shall have an ADA compliant grate.
- B. Trench drain, frame, and grate shall be H-20 heavy truck traffic rated in vehicle areas.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in section 312317 Trenching.

3.2 INSTALLATION

- A. General: Install inlet complete with appurtenances and accessories indicated.
- B. Install public inlets per City of Beaverton and Clean Water Services Standards.
- C. Install private inlets per Manufacturer's recommendation and Oregon Plumbing Specialty Code.

3.3 CONNECTIONS

- A. Pothole prior to construction to verify location, size and depth of existing piping. Notify Engineer if location, size, or depth of existing pipe is different than shown on the plans.

3.4 FIELD QUALITY CONTROL

- A. Inspection shall be per City of Beaverton and Clean Water Services Standards.

3.5 CLEANING

- A. Clean dirt and superfluous material from interior of piping prior to testing.

3.6 TESTING AND ACCEPTANCE

- A. Testing shall be in conformance with City of Beaverton Standards, Clean Water Services Standards, and Oregon Plumbing Specialty Code.

END OF SECTION 334400

SECTION 334900 – STORM DRAINAGE STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

- A. This section specifies requirements for storm drainage structures for a gravity flow drainage system.

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specifications Sections, apply to this Section.
- B. Applicable sections of the current Oregon Plumbing Specialty Code, City of Beaverton Design Manual and Standard Drawings, and the Clean Water Services Design and Construction Standards.
- C. All work shall be done in accordance with these specifications and in conformity with the plans.
- D. Section 334100 Storm Drainage Piping.

1.3 SUBMITTALS

- A. Product Data.
- B. Shop Drawings for Manholes

1.4 DELIVERY, STORAGE AND HANDLING

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

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other marking or specified testing agency.
- B. Comply with NSF/ANSI 14, "Plastic Piping System Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.

1.6 PROJECT CONDITIONS

- A. Interruption of Utility Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Owner no fewer than two days in advance of proposed interruption of storm drainage service.

PART 2 - PRODUCTS

2.1 Polyvinyl Chloride Pipe (PVC)

- A. Pipe and Fittings 4 inches to 15 inches shall be PVC SDR 35, conforming to ASTM D3034.
- B. Joints: PVC pipe shall have integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. Elastomeric gaskets shall conform to ASTM D3212.

2.2 Manholes

- A. Manhole components shall conform to Clean Water Services Design and Construction Standards and City of Beaverton Standards.
- B. All steps within structures must comply with OSHA standards for fixed metal, individual rung ladders (OAR 437), and CWS, except that there shall be no more than 24 inches between the top of the casting and the rung of the top step.
- C. All precast manhole riser sections shall conform to the requirements of ASTM C478.
- D. All poured in place concrete shall have a 28 day strength of 3000 psi, and a slump of 2 inches to 4 inches.
- E. All joints shall be sealed with preformed gaskets such as Kent-Deal #2, Ram-Neck, or an approved equal conforming to federal specifications SS-S00210.
- F. All pipe connections to manhole shall be water tight.
- G. Watertight / tamper proof manhole frame and cover shall be used in all easement and off-street areas.

2.3 Cleanouts

- A. Cleanout components shall conform to Clean Water Services and City of Beaverton Standards.
- B. Cleanout stand pipe shall be the same material and size as the mainline, up to and including 8 inch pipe. Mainline greater than 8 inches shall have an 8 inch standpipe.

- C. Cleanout frame and cover shall have a concrete collar.
- D. Cleanouts shall have a gas- and watertight threaded plug in conformance with Plumbing Code.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavation, trenching, and backfilling are specified in section 312317 Trenching.

3.2 MANHOLE INSTALLATION

- A. General: Install manholes complete with appurtenances and accessories indicated.
- B. Install precast concrete manhole sections with sealants according to ASTM C891, City of Beaverton Standards, and Clean Water Services Standards.

3.3 CLEANOUT INSTALLATION

- A. General: Install cleanout complete with appurtenances and accessories indicated, and in conformance with the City of Beaverton and Clean Water Services Standards.
- B. Install cleanouts where indicated on the drawings and per Oregon Plumbing Specialty Code.

3.4 CONNECTIONS

- A. Pothole prior to construction to verify location, size and depth of existing piping. Notify Engineer if location, size, or depth of existing pipe is different than shown on the plans.

3.5 FIELD QUALITY CONTROL

- A. Inspection shall be per the City of Beaverton and Clean Water Services Standards.

3.6 CLEANING

- A. Clean dirt and superfluous material from interior of piping prior to testing.

3.7 TESTING AND ACCEPTANCE

- A. Testing shall be in conformance with the City of Beaverton, Clean Water Services Standards, and Oregon Plumbing Specialty Code.

ACMA
BEAVERTON SCHOOL DISTRICT
BEAVERTON, OREGON

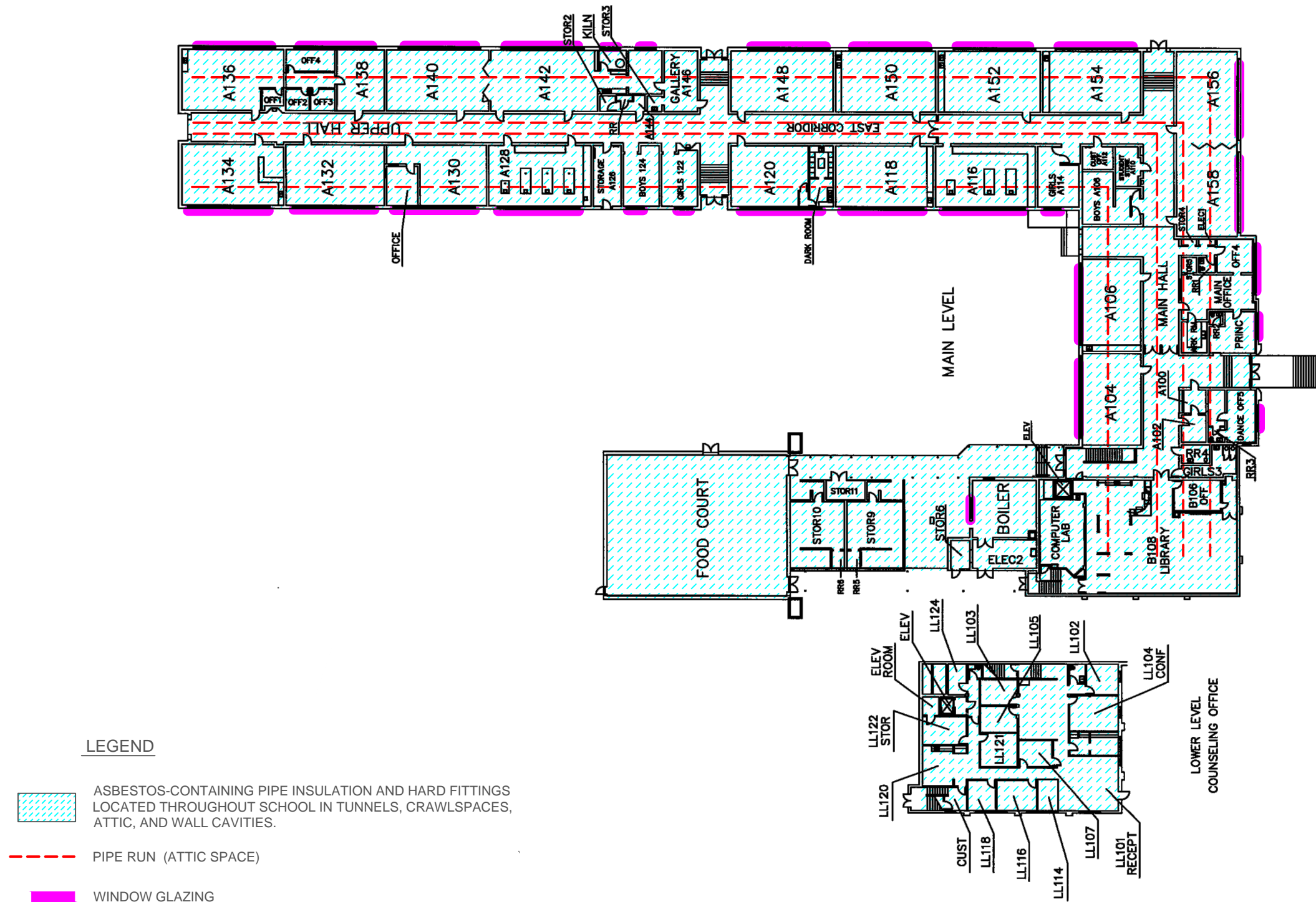
DLR GROUP PROJECT NO. 74-18109-00

BID AND PERMIT SET




END OF SECTION 334900



NOTE: SCALE AND LOCATIONS ARE APPROXIMATE



LEGEND

-  ASBESTOS-CONTAINING PIPE INSULATION AND HARD FITTINGS LOCATED THROUGHOUT SCHOOL IN TUNNELS, CRAWLSPACES, ATTIC, AND WALL CAVITIES.
-  PIPE RUN (ATTIC SPACE)
-  WINDOW GLAZING

NOTE: SCALE AND LOCATIONS ARE APPROXIMATE

DATE		01/10/18	FIGURE NUMBER		2.2
PROJECT NO.		293356	ASBESTOS-CONTAINING MATERIALS LOCATION MAP		
DRAWN BY		SC	Arts & Communication Magnet Academy		
CHECKED BY		MC	11375 SW Center Street		
CHECKED BY		RL	Beaverton, OR 97005		

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June 25, 2018

6111 GEOTECHNICAL RPT

Beaverton School District
16550 SW Merlo Road
Beaverton, OR 97006

Attention: Leslie Imes

**SUBJECT: Geotechnical Investigation and Site-Specific Seismic Hazard Study
Beaverton School District
Arts and Communications Magnet Academy
11375 SW Center Street
Beaverton, Oregon**

At your request, GRI completed a geotechnical investigation for the proposed improvements to the Arts and Communications Magnet Academy (ACMA), located in Beaverton, Oregon. The general location of the site is shown on the Vicinity Map, Figure 1. The investigation was conducted to evaluate subsurface conditions at the site and to develop recommendations for design and construction of the site development including: earthwork, subsurface drainage, excavations, and design and construction of foundations, retaining walls, pavements, and stormwater facilities. Our investigation included a review of available geologic information for the site, subsurface explorations, laboratory testing, and engineering analyses. As part of our investigation, GRI completed a site-specific seismic hazard evaluation to satisfy the requirements of the 2012 International Building Code (IBC), which was adopted by the 2014 Oregon Structural Specialty Code (OSSC). This report describes the work accomplished and provides our conclusions and recommendations for design and construction of the project.

BACKGROUND INFORMATION

GRI reviewed available geotechnical information at the project site as part of this investigation. GRI previously completed a Phase II Environmental Site Assessment on the ACMA campus, which is summarized in our September 19, 2016, report to Beaverton School District, titled, "Phase II Environmental Site Assessment, Arts and Communications Magnet Academy (ACMA), 11375 SW Center Street, Beaverton, Oregon."

In addition, GRI reviewed GeoDesign, Inc.'s, August 15, 2007, report to the Beaverton School District completed at the project site, titled, "Report of Geotechnical Engineering Services, Proposed Arts and Communication Magnet Academy Improvements, 11375 SW Center Street, Beaverton, Oregon."

PROJECT DESCRIPTION

The Beaverton School District plans to construct a new 80,000-sq-ft, two-story, steel classroom building within the central portion of the existing school property. The new structure is planned east of the auditorium/theatre building. We understand the existing auditorium/theatre building will remain in its current configuration. All other existing buildings will be demolished as part of this project. The project architect and structural engineer, DLR Group, indicated the new building will have maximum column and wall loads of about 260 kips and 1.5 kips/ft, respectively. The existing parking lot on the east side of the

school will be demolished and expanded slightly to the west towards the new building. A new parking lot is also planned to the south of the proposed building. On-site disposal of stormwater is being considered through shallow infiltration facilities being considered within the northern, eastern, and southern portions of the site. The locations of the planned improvements, which are based on conceptual plans provided by DLR Group, are shown on the Site Plan, Figure 2, with the exception of the locations of infiltration facilities. We anticipate the new improvements will be established at or near existing site grades, and cuts and fills to establish grades across the site will be minimal.

SITE DESCRIPTION

Topography and Surface Conditions

The ACMA campus is bordered by CE Mason Wetlands Park to the north, SW 13th Avenue to the east, SW Center Street to the south, and residential apartments to the west. Based on review of the existing conditions survey, the ground surface generally slopes downward gradually from about elevation 219 ft near the northeast corner of the site to about elevation 196 ft near the southwest corner of the site. All elevations noted in this report reference the North American Vertical Datum of 1988 (NAVD 88).

The campus consists of several one-story buildings spread out across the site. The existing auditorium/theatre building is located towards the southwest portion of the site. The main school building forms an approximate L-shape to the east of the auditorium/theatre building. An asphalt concrete (AC)-paved courtyard is located near the center of the site. The northwestern and eastern sides of the site are currently being used as AC-surfaced parking lots. An AC-surfaced access drive is located along the southern and western sides of the site. The northeastern portion of the site is currently a grass field.

Geology

Near-surface soils at the site are mapped as catastrophic flood deposits derived from the Missoula glacial outburst floods (Madin et al., 2006). The flood deposits in the project area consist primarily of silt with varying percentages of clay and fine-grained sand and are referred to as Willamette Silt. The Hillsboro Formation, which consists of clay with variable silt and sand content, underlies the Willamette Silt. Based on our experience in the project area, the Hillsboro Formation is present at depths of 20 to 25 ft in the vicinity of the project.

SUBSURFACE CONDITIONS

General

Subsurface materials and conditions at the site were investigated on May 29 and 30, 2018, with seven borings designated B-1 through B-7, and one cone penetration test (CPT) probe designated CPT-1. The borings were advanced to depths of 5.5 to 41.5 ft, and the CPT probe was advanced to a depth of about 71.7 ft. The approximate locations of the explorations are shown on the Site Plan, Figure 2. A detailed discussion of the field exploration and laboratory testing program for this investigation are described in Appendix A. Logs of the explorations are provided on Figures 1A through 8A. The terms and symbols used to describe the soils encountered in the borings are defined in Table 1A and the attached legend. The terms used for the classification of soil in the CPT are provided in Table 2A.

Soils

For the purpose of discussion, the materials disclosed by the borings have been grouped into the following major categories based on their physical characteristics and engineering properties. The data from the CPT

soundings were also reviewed, and the depths and consistencies of each of the major categories were generally consistent with the conditions encountered in the borings.

- 1. PAVEMENT**
- 2. SILT (Fill)**
- 3. SILT (Willamette Silt)**
- 4. Silty CLAY (Hillsboro Formation)**

1. PAVEMENT. Borings B-4 through B-6 were drilled through the existing AC-surfaced courtyard and encountered 4 in. of AC pavement underlain by 6 in. of crushed-rock base course (CRB).

2. SILT (Fill). Silt fill was encountered at the ground surface in boring B-1 and extends to the maximum depth explored in the boring of 5.5 ft. The silt fill is brown and contains trace to some clay and a trace of fine-grained sand. Gravel and concrete fragments were encountered in the silt fill. Standard Penetration Test (SPT) N-values of 7 and 10 blows/ft indicate the relative consistency of the silt fill is medium stiff to stiff. The moisture content of the fill ranges from about 26 to 33%.

3. SILT (Willamette Silt). Silt soils of the Willamette Silt Formation were encountered at the ground surface in borings B-2, B-3, and B-7, and beneath the pavement in borings B-4 through B-6, and extends to depths ranging from 5.5 to 22.5 ft. Borings B-3, B-6, and B-7 were terminated in the silt at a depth of 5.5 ft. The silt soils are primarily brown and include varying percentages of clay and fine-grained sand, ranging from a trace of clay to clayey and up to some fine-grained sand. The silt in borings B-3 and B-7 contains roots. SPT N-values ranging from about 2 to 11 blows/ft, Torvane shear strength values ranging from 0.25 to 0.55 tsf, and CPT tip resistances of 6 to 60 tsf indicate the relative consistency of the silt ranges from soft to stiff and is typically medium stiff. The natural moisture content of the silt ranges from about 28 to 41%. Atterberg limits testing was performed on three selected samples of the silt and the results are summarized on the Plasticity Chart, Figure 9A, and in Table 3A in Appendix A. Atterberg limits testing on the silt samples indicates the silt has a liquid limit ranging from about 27 to 32% and a plasticity index ranging from about 2 to 7%, which indicates the silt has a low to moderate plasticity. Shear-wave velocity measurements recorded in the silt in CPT-1 range from about 602 ft/second at a depth of about 6.6 ft below the ground surface to a maximum of about 898 ft/second at a depth of about 19.7 ft.

Consolidation tests were conducted on samples of silt from depths of about 7.5 and 11.5 ft in borings B-4 and B-2, respectively. Test results indicate the soil is heavily overconsolidated and has a low compressibility in the preconsolidated range of stresses and a moderate compressibility in the normally consolidated range of stresses, see Figures 10A and 11A.

4. CLAY (Hillsboro Formation). Clay of the Hillsboro Formation was encountered beneath the silt in borings B-2, B-4, and B-5 at depths ranging from 20.8 to 22.5 ft, and extends to the maximum depths explored in the borings ranging from 40 to 41.5 ft. The clay also extends to the maximum depth explored in CPT-1 of 71.7 ft. The clay is generally brown to gray with yellow-brown and black mottling and contains a variable silt and sand content that ranges from some silt to silty and trace to some fine- to coarse-grained sand. Layers of sand and silty sand were encountered within this unit below a depth of about 55 ft in the CPT probe. SPT N-values ranging from 5 to 27 blows/ft, Torvane shear strength values ranging from 0.50 to 0.55 tsf, and CPT tip resistances of 18 to greater than 60 tsf indicate the general consistency of the clay is medium stiff to very

stiff. The natural moisture of the clay ranges from about 22 to 35%. Atterberg limits testing was performed on a selected sample of clay and the results are summarized on Figure 9A and in Table 3A. Atterberg limits testing on the sample of clay indicates the clay soil has a liquid limit about 47% and a plasticity index of 30%, indicating the clay has high plasticity. Shear-wave velocity measurements recorded in the clay in CPT-1 were at least 800 ft/second and generally increased with depth.

Groundwater

Groundwater was encountered at depths between about 9.9, 10, and 11.6 ft in borings B-2, B-4, and B-5 at the time of drilling. Groundwater was not encountered in the remaining borings. We anticipate static groundwater levels at the site are generally at a depth of about 10 ft below the existing ground surface; however, localized perched conditions may occur at shallower depths in the fill and silt during periods of heavy or prolonged rainfall.

Infiltration Testing

Falling head infiltration testing was completed on May 30, 2018, using the encased falling head infiltration method. The tests were conducted in shallow borings B-1, B-3, B-6, and B-7 at a depth of about 5.5 ft below the ground surface. Details of the infiltration testing methods are provided in Appendix A. GRI did not observe a measureable drop in water level in borings B-3, B-6, and B-7 over the course of testing. In boring B-1, the average rate of infiltration over the final test was observed to be about 0.1 in./hour.

CONCLUSIONS AND RECOMMENDATIONS

General

The explorations made for this investigation indicate the site is typically mantled by medium-stiff silt that is underlain by stiff to very stiff clay. Localized zones of fill may be present across portions of the site. Groundwater was encountered at depths of about 9.9 to 11.6 ft during drilling and we anticipate perched groundwater conditions may approach the ground surface following periods of heavy or prolonged precipitation and during the wet months, which is common during seasonally high precipitation from late fall through early spring.

In our opinion, foundation support for the new building can be provided by conventional spread and wall foundations established in firm, undisturbed native soil or compacted structural fill. The primary geotechnical considerations associated with the proposed improvements include the presence of fine-grained soils that are sensitive to moisture content and are easily disturbed by construction activities and shallow groundwater conditions likely present over portions of the year. The following sections of this report provide our conclusions and recommendations for earthwork and design and construction of foundations.

Site Preparation and Grading

Demolition of the existing buildings and improvements within the limits of the new structures, retaining walls, and paved areas should include the removal of existing pavements, floor slabs, foundations and walls, underground utilities, and associated unsuitable backfill. Excavations made during demolition to remove existing improvements should be backfilled with structural fill. Any soil disturbed during the demolition process should be removed and replaced with structural fill.

In unimproved areas, the ground surface within areas of mass grading or within the limits of proposed structures, retaining walls, hardscape, or pavements should be stripped of vegetation, surface organics, and loose surface soils. Strippings will not be suitable for use as structural fill and should be disposed of off site or used in landscape areas. We anticipate the average stripping depth will be on the order of 4 to 6 in. to remove the surface organics. Deeper grubbing will be necessary to remove stumps and heavy tree roots.

Following stripping, grubbing, or excavation to subgrade level, the exposed subgrade should be evaluated by a member of GRI's engineering staff. Proof rolling with a loaded dump truck may be included as part of the evaluation. Soft areas should be overexcavated and replaced with structural fill as described below. During and following stripping and excavation, the subcontractor must use care to protect the subgrade from disturbance by construction traffic, particularly during wet weather. Areas of soft subgrade, unsuitable fill, or otherwise unsuitable materials should be overexcavated to firm soil and backfilled with structural fill. Due to the moisture-sensitive nature of the fine-grained silt soils that mantle the site, site preparation and earthwork phases of this project should be accomplished during the dry summer months, typically extending from June to mid-October. Our experience indicates the moisture content of the upper 2 to 4 ft of the silt soils will decrease during warm, dry weather. However, below this depth, the moisture content tends to remain relatively unchanged and well above the optimum moisture content for compaction. As a result, the contractor must employ construction techniques that prevent or minimize disturbance and softening of the subgrade soils. The use of a track-mounted excavator equipped with a smooth-edged bucket for excavation with the concurrent placement of granular work pads tends to minimize the potential for subgrade disturbance. If the subgrade is disturbed during construction, soft, disturbed soils should be overexcavated to firm soil and backfilled with structural fill.

Due to the potential of perched and relatively shallow groundwater conditions across the site, it should be anticipated that wet soils with associated seepage may occur in most cut areas. The silt soils, when saturated, are typically easily disturbed and become unstable under most construction traffic and difficult to place and compact as structural fill.

To prevent disturbance and softening of the fine-grained subgrade soils during wet weather or ground conditions, the movement of construction traffic should be limited to granular haul roads and work pads. In general, a minimum of 18 to 24 in. of relatively clean, granular material is required to support concentrated construction traffic, such as dump trucks and concrete trucks, and protect the subgrade. A 12-in.-thick granular work pad should be sufficient to support occasional light truck traffic and low-volume construction operations. We recommend placement of a woven geotextile separation fabric on the exposed subgrade prior to placement and compaction of the granular work pad.

Permanent cut and fill slopes should be constructed at 2H:1V (Horizontal to Vertical) or flatter. Temporary cut slopes up to about 10 ft tall should be 1H:1V or flatter, and temporary cut slopes greater than 10 ft tall should be 1.5H:1V or flatter. If temporary and permanent slopes cannot be maintained due to existing or planned improvements, GRI should be contacted to provide shoring recommendations.

Structural Fill

General. All fill within building, hardscape, pavement, and retaining wall areas should be placed as compacted structural fill. The structural fill should extend at least 4 and 2 ft beyond the building and pavement limits, respectively. All structural fill materials should be compacted to at least 95% of the

maximum dry density and at a moisture content within about 3% of optimum, as determined by ASTM International (ASTM) D698. The optimum moisture content varies with gradation and should be evaluated during construction by performing ASTM D698 laboratory testing on fill material used for the project. Fill material that is not near the optimum moisture content should be moisture-conditioned prior to compaction. Coarse, granular fill should be compacted until well-keyed. No brush, roots, construction debris, or other deleterious material should be placed within the structural fills. The earthwork contractor's compactive effort should be evaluated on the basis of field observations, and lift thicknesses should be adjusted accordingly to meet compaction specifications. GRI's geotechnical engineering staff should evaluate compaction of each lift of the structural fill. Recommendations for structural fill are provided in the following sections.

On-Site Soils. Unless an admixture such as lime or cement is used, the on-site soils can only be used to construct structural fills during warm, dry weather. The natural moisture content of the on-site soils will likely exceed the optimum moisture content throughout the majority of the year; hence, some drying will be required to meet the above requirements for proper compaction even during the summer months. The required drying can best be accomplished during dry weather by spreading and aerating the material in thin lifts. Fine-grained soils should be placed in lifts less than 9 in. thick and compacted with segmented-pad rollers. Hand-operated tamping units should be used adjacent to embedded structures and in confined areas.

Granular Fill. Imported granular fill materials used as structural fill should consist of sand, gravel, or fragmental rock with a maximum size on the order of 3 in. and with not more than 5% passing the No. 200 sieve (washed analysis). Granular structural fill should be limited to a maximum size of about 1½ in. when used as utility backfill or compacted with hand-operated equipment. Material satisfying these requirements can usually be placed during periods of wet weather. The first lift of granular fill placed over a fine-grained subgrade should be about 18 in. thick and subsequent lifts about 12 in. thick when using medium- to heavy-weight vibratory rollers. We recommend limiting lift thicknesses to less than 8 in. when using hand-operated vibratory plates.

Free-Draining Fill. Free-draining material should have less than 2% passing the No. 200 sieve (washed analysis). Examples of materials that would satisfy this requirement include ¾- to 1¼-in. or 1½- to ¾-in. crushed drain rock.

Foundation Support

As previously indicated, the maximum total column and wall loads for the new building will be on the order of 260 kips and 1.5 kips/ft, respectively. In our opinion, foundation support for the building can be provided by conventional column and continuous wall footings using an allowable bearing value of 2,500 psf. This bearing pressure has a factor of safety of at least 3 against a bearing capacity failure and assumes the foundation is founded on firm native or engineered fill consisting of on-site silt soil or imported granular material. This value applies to the total of dead load and/or frequently applied live loads and can be increased by one-half for the total of all loads: dead, live, and wind or seismic.

Spread and wall footings should be established in firm, undisturbed native soil or compacted structural fill at a minimum depth of 18 in. below the lowest adjacent finished grade. The footing width should not be less than 24 in. for isolated column footings and 18 in. for wall footings. Excavations for all foundations should be made with a smooth-edged bucket, and all footing excavations should be observed by personnel from GRI. Soft or otherwise unsuitable material encountered at foundation subgrade level should be

overexcavated and backfilled with granular structural fill. We recommend installing a minimum 3-in.-thick layer of compacted crushed rock in the bottom of all footing excavations to protect the subgrade from disturbance or softening during construction.

We estimate the total settlement of spread footings will be less than 1 in. for footings supporting column and wall loads of up to 260 kips and 1.5 kips/ft, respectively. Differential settlement between adjacent comparably loaded footings should be less than half the total settlement.

Horizontal shear forces can be resisted partially or completely by frictional forces developed between the base of spread footings and the underlying soil. The total shearing resistance between the foundation footprint and the soil should be taken as the normal force, i.e., the sum of all vertical forces (dead load plus real live load) times the coefficient of friction between the soil and the base of the footing. We recommend an ultimate value of 0.40 and 0.30 for the coefficient of friction for footings cast on a minimum of 6 in. of granular structural fill or firm silt subgrade, respectively. If additional lateral resistance is required, passive earth pressures against embedded footings can be computed on the basis of an equivalent fluid having a unit weight of 250 pcf. This design passive earth pressure would be applicable only if the footing is cast neat against undisturbed soil, or if backfill for the footings is placed as granular structural fill. This value also assumes the ground surface in front of the foundation is horizontal, i.e., does not slope downward away from the toe of the footing.

Subdrainage and Floor Support

Building slab-on-grade floors established at or above adjacent final site grades should be underlain by a minimum 8 in. of free-draining, clean, angular rock to provide a capillary break and reduce the risk of damp floors. This material should consist of angular rock, such as 1½- to ¾-in. crushed rock, with less than 2% passing the No. 200 sieve (washed analysis), and should be placed in one lift and compacted to at least 95% of the maximum dry density as determined by ASTM D698, or until well-keyed. The free-draining rock can be capped with 2 in. of compacted ¾-in.-minus crushed rock to provide a more stable working surface. In areas where floor coverings will be provided or moisture-sensitive materials are stored, it would be appropriate to also install a vapor-retarding membrane. The membrane should be installed as recommended by the manufacturer. In addition, a foundation drain should be installed around the building perimeter to collect water that could potentially infiltrate beneath the foundations and should discharge to an approved storm drain.

Structures established below final site grades should be provided with a subdrainage system to reduce hydrostatic pressure and the risk of groundwater entering through embedded walls and floor slabs. Typical subdrainage details for embedded structures are shown on Figure 3. The figure shows peripheral subdrains to drain embedded walls and an interior granular drainage blanket beneath the concrete floor slab, which is drained by a system of subslab drainage pipes. All groundwater collected should be drained by gravity or pumped from sumps into the storm sewer system. If the water is pumped, an emergency power supply should be included to prevent flooding due to a power loss.

To evaluate isolated point loading on the floor slabs, it is our opinion a coefficient of subgrade reaction, k , of about 175 pci is appropriate to characterize the subgrade support with a minimum 8 in. of compacted crushed rock beneath the slabs.

Lateral Earth Pressures

Design lateral earth pressures against the walls of embedded structures or retaining walls depend on the drainage condition provided behind the wall and the type of construction, i.e., the ability of the wall to yield. The two possible conditions regarding drainage include providing drainage to the area behind the embedded wall or designing the structure to be watertight. In the event that structures are designed to be watertight, it should be assumed the water table can rise to the ground surface at the site.

The two possible conditions regarding the ability of the wall to yield include the at-rest and active earth pressure cases. The at-rest earth pressure case is applicable to a wall that is relatively rigid and laterally supported at the top and bottom and therefore unable to yield, such as a basement wall with the top of the wall tied to the building floor slab. The active earth pressure case is applicable to a wall capable of yielding slightly away from the backfill by either sliding or rotating about its base, such as a conventional cantilevered retaining wall.

Assuming the top of the backfill will be horizontal and the backfill completely drained, yielding and non-yielding walls can be designed on the basis of a hydrostatic pressure based on an equivalent fluid unit weight of 35 and 55 pcf, respectively. A uniform vertical surcharge pressure of 250 psf should be assumed for construction equipment in the backfill area. Additional loading due to surcharge loads should be added in accordance with the criteria shown on Figure 4.

Seismic loading on retaining walls depends on the type of wall and construction techniques. The Agusti and Sitar (2013) method was used to develop the seismically induced lateral earth pressures. The method applies a triangular lateral earth pressure distribution with a pressure of $0H$ (psf) at the ground surface and a maximum pressure of $7H$ and $16H$ (psf) for yielding and non-yielding walls, respectively, at the base of the wall, where H is the height of the wall. These pressures assume the backfill behind the structure is horizontal. The resultant force acts at a point above the base of the wall equal to one-third of the wall height.

Drainage for walls should be provided by a perforated drain pipe located at the bottom of the backfill to drain all groundwater by gravity, or pumped from sump pits into the storm sewer system. Wall backfill should consist of clean, granular, structural fill material compacted to about 95% of the maximum dry density determined by ASTM D698. A 2-ft-thick blanket of open-graded drain rock with less than about 2% passing the No. 200 sieve (washed analysis) should be placed against the wall. A geotextile separation fabric should be installed between the drainage blanket and the general wall backfill. Overcompaction of backfill behind the walls should be avoided. Heavy compactors and large pieces of construction equipment should not operate within 4 ft of any embedded walls. As an alternative approach, wall drainage can be provided by the installation of commercially available drainage layer material on embedded walls. Drainage strips that are 18 in. wide and installed at a center-to-center spacing of 8 ft would be suitable for this purpose.

Where it is not practical to drain the backfill for structures such as utility vaults, and where the embedded walls will be designed to be watertight, yielding and non-yielding walls can be designed for a hydrostatic pressure based on an equivalent fluid unit weight of 80 and 90 pcf, respectively. These pressures assume the backfill behind the structure is horizontal. A watertight structure should also be designed to resist buoyancy. A common method used to resist buoyancy is to increase the thickness of the base slab and/or extend the base slab beyond the sidewall of the structure. The forces resisting uplift would include the weight of the structure as well as the buoyant weight of the backfill material placed directly over the portion of the

base slab that extends beyond the wall of the structure. The effective weight of submerged backfill should be evaluated using a buoyant unit weight of 63 pcf, which assumes all backfill consists of granular material.

Utilities

In our opinion, there are four major considerations associated with design and construction of new utilities:

- 1) Provide stable excavation side slopes or support for trench sidewalls to minimize loss of ground.
- 2) Provide a safe working environment during construction.
- 3) Minimize post-construction settlement of the utility and ground surface.
- 4) Presence of fill in trench excavations.

The method of excavation and design of trench support are the responsibility of the contractor and subject to applicable local, state, and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) excavation and trench safety standards. The means, methods, and sequencing of construction operations and site safety are also the responsibility of the contractor. The information provided below is for the use of our client and should not be interpreted to mean we are assuming responsibility for the contractor's actions or site safety. All excavations should be sloped or properly shored. Groundwater seepage, running soil conditions, and unstable trench sidewalls or soft trench subgrades, if encountered, will require dewatering of the excavation and trench sidewall support. The impact of these conditions can be minimized by completing trench excavation during the summer months when groundwater levels are lowest, and by minimizing the depth of the trenches. Some overexcavation of the trench bottom may also be necessary to permit the installation of stabilization material to provide a uniform trench bottom. Clean, 4-in.-minus crushed rock over a geotextile fabric is typically used for this purpose. The actual required depth of overexcavation will depend on the contractor's method of operation and the conditions encountered, and should be established at the time of construction. We anticipate groundwater inflow, if encountered, can generally be controlled by pumping from sumps.

Backfill placed in utility trench excavations within the limits of the pavements or structures should consist of sand, sand and gravel, or crushed rock with a maximum size of up to 1½ in. and not more than 5% passing the No. 200 sieve (washed analysis). The granular backfill should be compacted to at least 95% of the maximum dry density as determined by ASTM D698. The use of excavator-mounted vibratory plate compactors (hoe-packs) is typically most efficient for compaction of trench backfill. Lift thicknesses should be evaluated on the basis of field density tests; however, particular care should be taken when operating excavator-mounted compactors to prevent damage to the newly placed utilities. Flooding or jetting the backfilled trenches with water to achieve the recommended compaction should not be permitted.

Pipes should be underlain by a minimum 6-in. thickness of good-quality bedding material. We recommend the bedding material and any pipe zone backfill consist of clean (not more than about 5% passing the No. 200 sieve, washed analysis), ¾-in.-minus crushed rock. The bottom of the excavation should be thoroughly cleaned to remove loose materials before installing the bedding material.

Pavement Design

General. We anticipate the existing parking lot on the eastern side of the school will be demolished and widened to the west towards the new building. In addition, a new parking lot is planned south of the proposed building. Specific information regarding the anticipated vehicle traffic (i.e., type and number) was not available at the time of our pavement evaluation. We have assumed the parking lots and driveway areas will be primarily subjected to automobile traffic. We anticipate portions of the pavement will be subjected to occasional heavy truck traffic, such as delivery and garbage trucks. In addition, portions of the pavement may also be subjected to school bus traffic. Based on our experience with similar projects and subgrade materials, we recommend the following pavement sections:

	Crushed-Rock Base Thickness, in.	AC Thickness, in.
Areas Subjected to School Bus Traffic	14	5
Areas Subjected to Occasional Heavy Truck Traffic	12	4
Areas Subject Primarily to Automobile Traffic and Parking	8	3

A geotextile fabric should be placed on the exposed subgrade prior to placement of the CRB unless the subgrade soil is cement treated.

The recommended pavement sections should be considered minimum thicknesses, and it should be assumed some maintenance will be required over the life of the pavement (15 to 20 years). These sections are based on the assumption that pavement construction will be accomplished during the dry season and after construction of the buildings has been completed. If wet-weather pavement construction is considered, it will likely be necessary to increase the thickness of the CRB to support construction equipment and protect the subgrade from disturbance. The recommended pavement sections are not intended to support extensive construction traffic, such as dump trucks and concrete trucks. Pavements subject to construction traffic may require repair.

For the recommended pavement sections, drainage is an essential aspect of pavement performance. We recommend all paved areas be provided with positive drainage to remove surface water and water within the base course. This will be particularly important in cut sections or at low points within the paved areas, such as at catch basins. Effective methods to prevent saturation of the base course materials include providing weep holes in the sidewalls of catch basins, subdrains in conjunction with utility excavations, and separate trench drain systems. We recommend the pavement work conform to Oregon Department of Transportation standards.

Prior to placing base course materials, all pavement subgrades should be evaluated by a member of GRI's engineering staff. This evaluation may include a proof roll with a fully loaded, 10-cy dump truck. Any soft areas detected during the evaluation should be overexcavated to firm ground and backfilled with compacted structural fill.

Provided the pavement sections supporting occasional heavy truck traffic or school buses are installed in accordance with the recommendations provided above, it is our opinion these pavement areas can support

infrequent traffic by an emergency vehicle having a gross vehicle weight (GVW) of up to 75,000 lbs. For the purposes of this evaluation, “infrequent” can be defined as once a month or less.

On-Site Disposal of Stormwater

Falling head infiltration tests were completed at a depth of about 5.5 ft in standpipes installed in borings B-1, B-3, B-6, and B-7 to obtain infiltration rates to evaluate on-site disposal of stormwater. As previously mentioned, no observable drop in water was observed in borings B-3, B-6, and B-7 during the testing and the infiltration rate in boring B-1 was about 0.1 in./hour. Based on the results of the infiltration testing, it is our opinion on-site infiltration of stormwater is not appropriate for the site.

Seismic Considerations

Code-Based Seismic Design Parameters. We understand the project will be designed in accordance with the 2012 IBC with the 2014 OSSC modifications. Seismic design in the 2012 IBC is based on the American Society of Civil Engineers (ASCE) Document 7-10, Minimum Design Loads for Buildings and Other Structures (ASCE 7-10). GRI completed a site-specific seismic hazard study in accordance with the 2012 IBC and 2014 OSSC. The results of our site-specific seismic hazard evaluation and recommended response spectrum for design are provided in Appendix B.

The IBC design methodology uses two spectral response coefficients, S_s and S_1 , corresponding to periods of 0.2 and 1.0 second, to develop the Risk-Targeted Maximum Considered Earthquake (MCE_R) structural response spectrum. The spectral response coefficients were obtained from the U. S. Geological Survey (USGS) Hazard Response Spectra Curves for the coordinates of 45.4948° N latitude and 122.7942° W longitude. The S_s and S_1 coefficients are 1.00 and 0.43 g, respectively. These spectral response coefficients are then adjusted for Site Class with the 0.2- and 1.0-second period site coefficients, F_a and F_v . In accordance with ASCE 7-10 Sections 20.3.1 and 20.4, the site is designated Site Class D. The 0.2- and 1.0-second period site coefficients, F_a and F_v , are 1.10 and 1.57, respectively, for Site Class D. The design-level response spectrum is calculated as two-thirds of the Site Class-adjusted MCE_R-level spectrum. The MCE_R-level and design-level response spectra coefficients are presented in the following table.

2012 IBC AND 2014 OSSC SEISMIC DESIGN RECOMMENDATIONS

Seismic Variable	Recommended Value
Site Class	D
MCE _R 0.2-Second Period Spectral Response Acceleration, S_{MS}	1.10 g
MCE _R 1.0-Second Period Spectral Response Acceleration, S_{M1}	0.68 g
Design-Level 0.2-Second Period Spectral Response Acceleration, S_{DS}	0.73 g
Design-Level 1.0-Second Period Spectral Response Acceleration, S_{D1}	0.45 g

Liquefaction and Cyclic Softening. Liquefaction is a process by which loose, saturated, granular materials, such as sand, and to a somewhat lesser extent, soft to medium-stiff, non-plastic and low-plasticity silts, temporarily lose strength during and immediately after a seismic event. Cyclic softening describes a relatively gradual and progressive increase in shear strain that occurs in normally consolidated to slightly

overconsolidated moderate-plasticity silts and clays as a result of seismic loading. Cyclic softening may result in elevated pore water pressures and a reduction of shear strength of sensitive silts and clays.

The potential for liquefaction and cyclic softening/failure potential of the fine-grained soils at the site was assessed using procedures outlined by Idriss and Boulanger (2008). The method developed by Idriss and Boulanger compares the undrained shear strength of the soil, corrected for earthquake magnitude and seismic loading effects, with the earthquake-induced shear stress. The risk of seismic-induced soil softening or liquefaction is low for saturated soils of the Willamette Silt Formation. Following a code-based earthquake, associated seismic-induced settlements are estimated on the order of about 1 in. In general, the deeper, stiffer, clayey soils of the Hillsboro Formation are not considered to be susceptible to significant soil-softening or liquefaction. Based on the relative consistency of soils at the site, we anticipate seismic-induced settlement will be relatively uniform across the site. Seismic-induced differential settlement between adjacent shallow foundations should be less than half of the total anticipated seismic-induced settlement at the ground surface.

DESIGN REVIEW AND CONSTRUCTION SERVICES

We welcome the opportunity to review and discuss construction plans and specifications for this project as they are being developed. In addition, GRI should be retained to review all geotechnical-related portions of the plans and specifications to evaluate whether they are in conformance with the recommendations provided in our report. In addition, to observe compliance with the intent of our recommendations, design concepts, and the plans and specifications, we are of the opinion that all construction operations dealing with earthwork and foundations should be observed by a GRI representative. Our construction-phase services will allow for timely design changes if site conditions are encountered that are different from those described in our report. If we do not have the opportunity to confirm our interpretations, assumptions, and analyses during construction, we cannot be responsible for the application of our recommendations to subsurface conditions that are different from those described in this report.

LIMITATIONS

This report has been prepared to aid the architect and engineer in the design of this project. The scope is limited to the specific project and location described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the earthwork and design and construction of foundations, slab-on-grade floors, retaining walls, and pavements. In the event that any changes in the design and location of the project elements as outlined in this report are planned, we should be given the opportunity to review the changes and to modify or reaffirm the conclusions and recommendations of this report in writing.

The conclusions and recommendations submitted in this report are based on the data obtained from the subsurface explorations made at the locations indicated on Figure 2 and from other sources of information discussed in this report. In the performance of subsurface investigations, specific information is obtained at specific locations at specific times. However, it is acknowledged that variations in soil conditions may exist between subsurface exploration locations. This report does not reflect any variations that may occur between these explorations. The nature and extent of variation may not become evident until construction. If, during construction, subsurface conditions differ from those encountered in the explorations, we should be advised at once so that we can observe and review these conditions and reconsider our recommendations where necessary.

Please contact the undersigned if you have any questions or comments regarding this report.

Submitted for GRI,



Renews 06/2018

A. Wesley Spang, PhD, PE
Principal

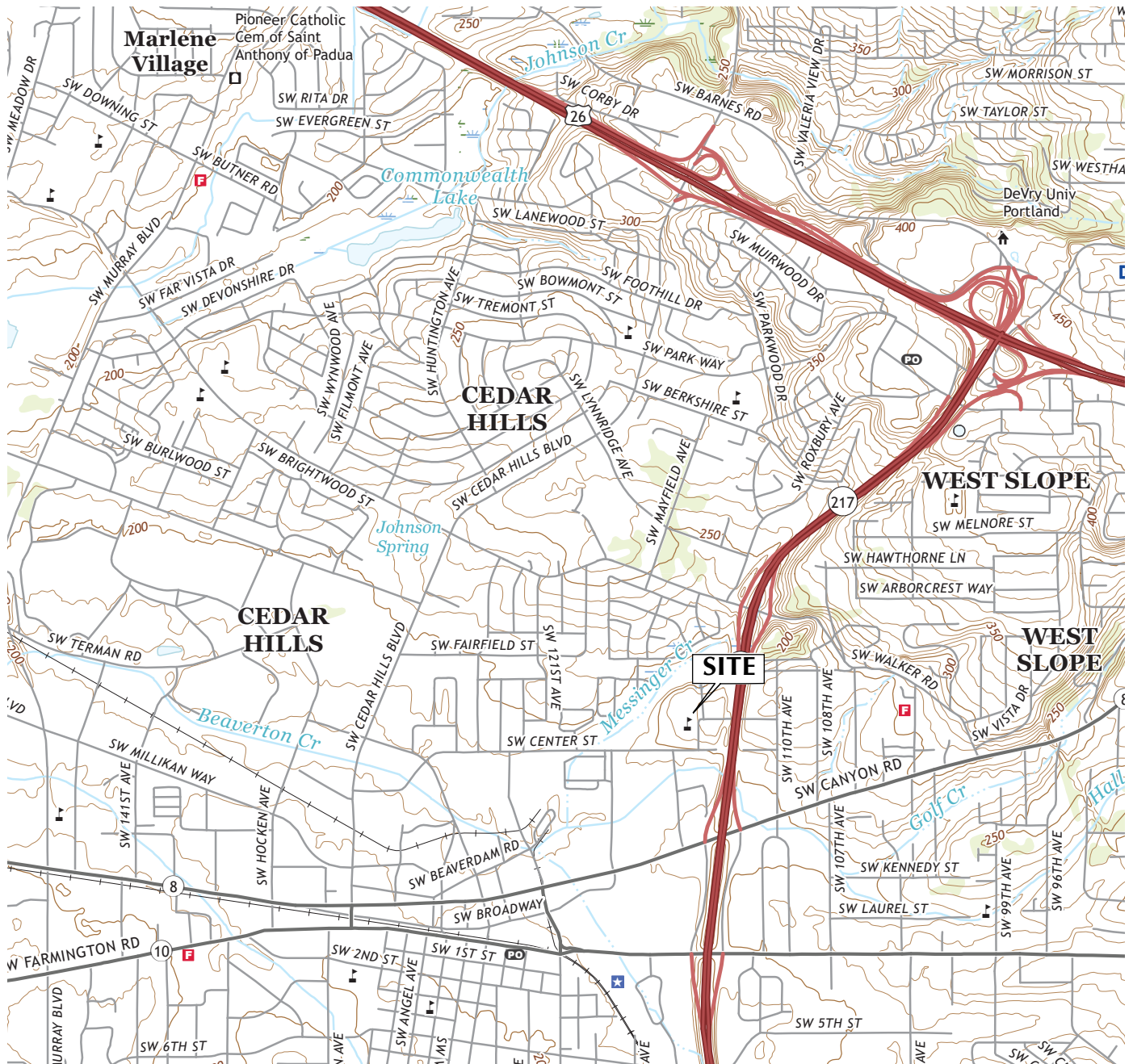
Brian Bayne, PE
Senior Engineer

Tadesse Meskele, PhD, PE
Project Engineer

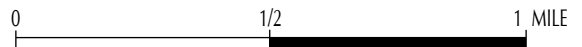
This document has been submitted electronically.

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- Agusti, G. C., and Sitar, N., 2013, Seismic earth pressures on retaining structures in cohesive soils: University of California, Berkeley, UCB GT 13-02.
- Idriss, I. M., and Boulanger, R. W., 2008, Soil Liquefaction during Earthquakes, Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.



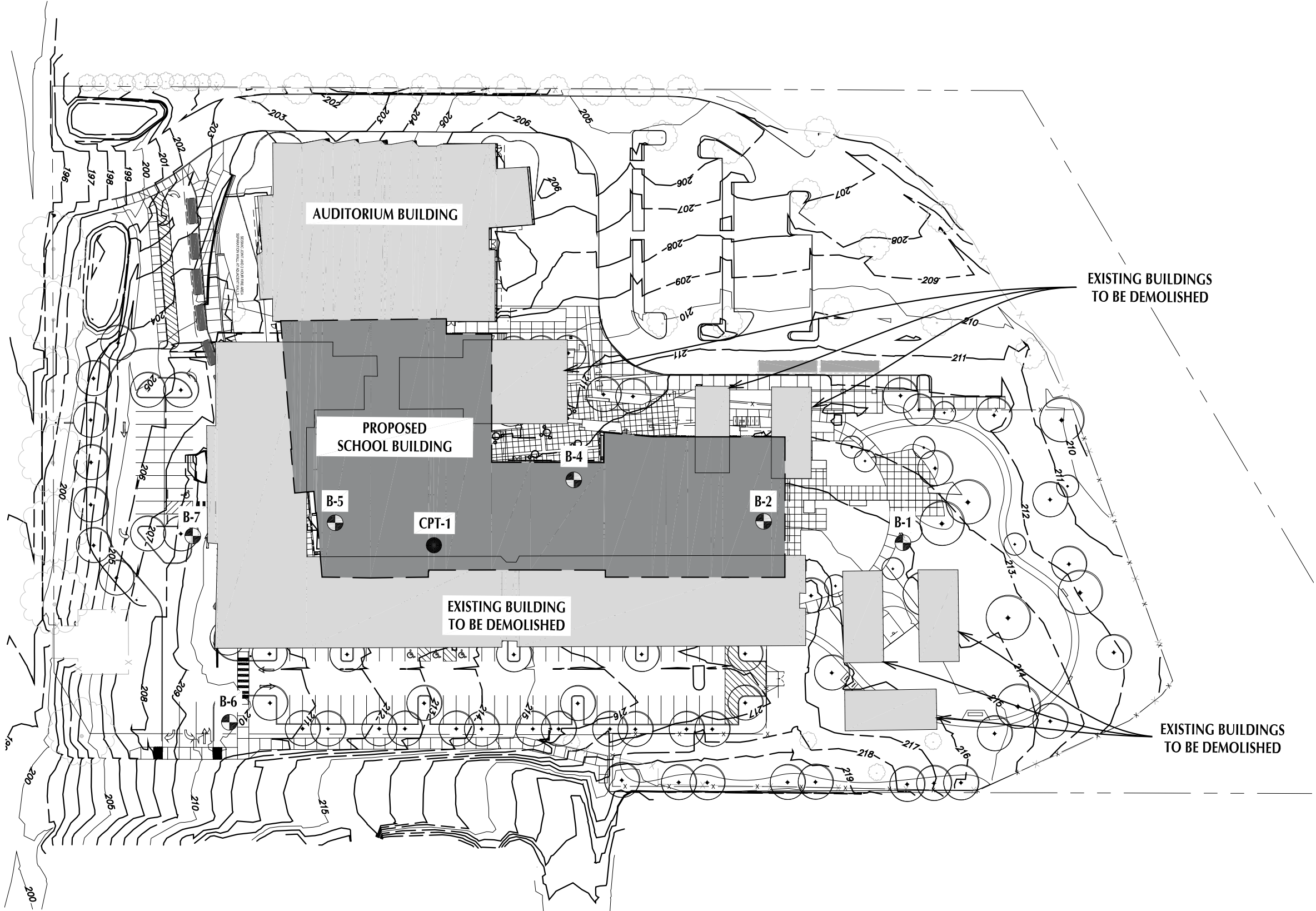
USGS TOPOGRAPHIC MAP
LINNTON, OREG. (2017)
BEAVERTON, OREG. (2017)





BEAVERTON SCHOOL DISTRICT
ARTS AND COMMUNICATION MAGNET ACADEMY (ACMA)

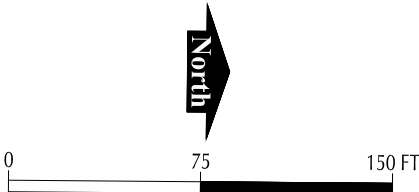
VICINITY MAP

PROJECT LOCATION: P:\6101-6200\6111 Beaverton Sch Distr ACMA\Drafting\SITE PLAN (FIG.2) 11 x 17.dwg



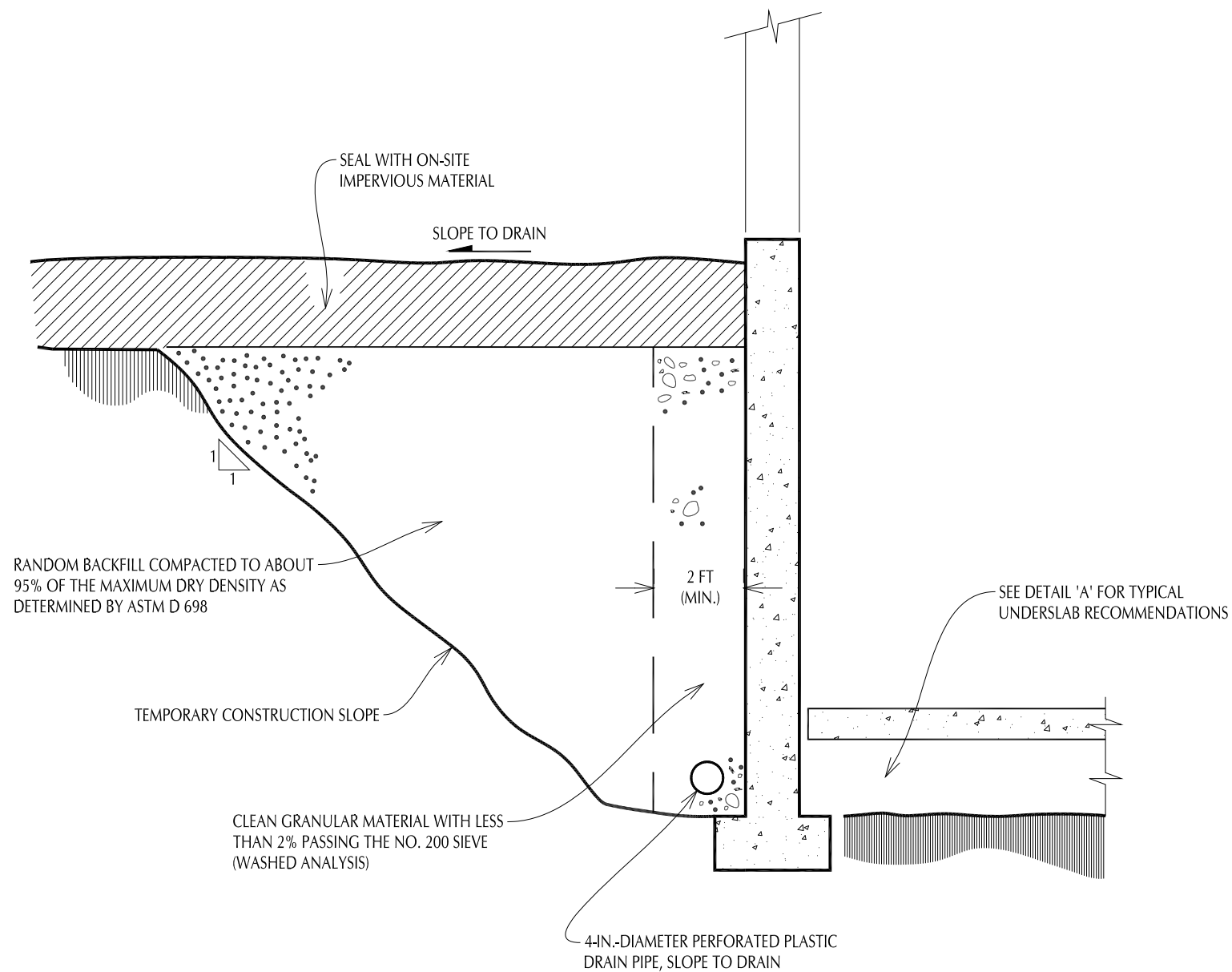
-  BORING COMPLETED BY GRI
(MAY 29, 2017)
-  CONE PENETRATION TEST COMPLETED BY GRI
(MAY 30, 2017)

SITE PLAN FROM FILE BY DLR GROUP, UNDATED

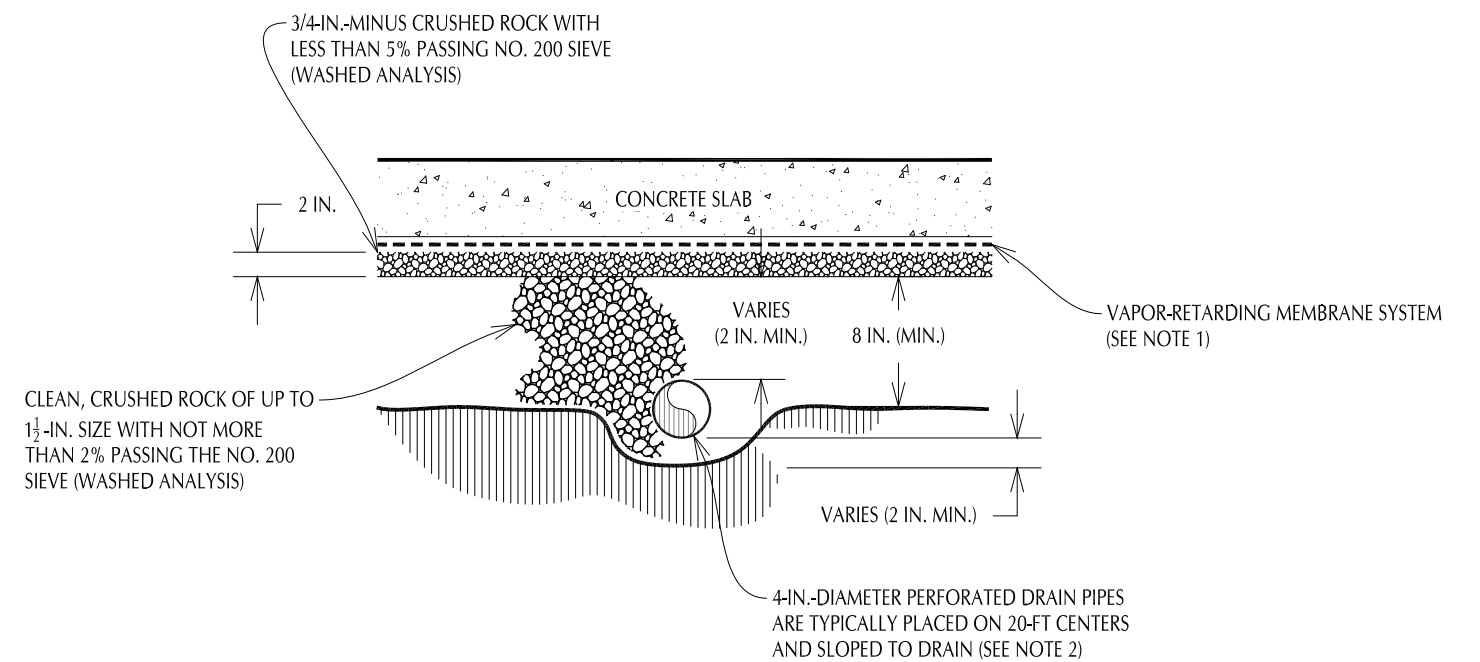


GRI BEAVERTON SCHOOL DISTRICT
ARTS AND COMMUNICATIONS MAGNET ACADEMY

SITE PLAN



PERIMETER DRAIN

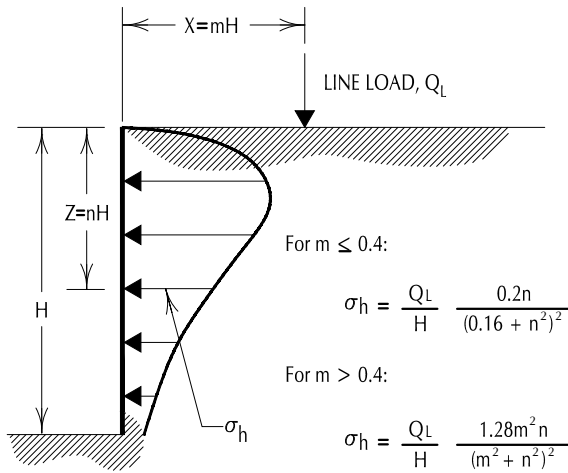


DETAIL 'A'
NOT TO SCALE

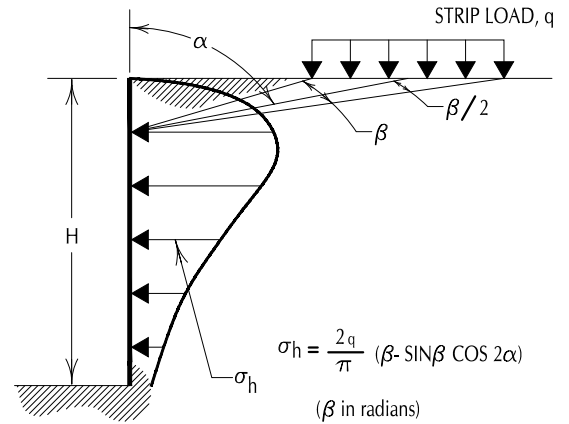
UNDERSLAB DRAIN

NOTES:

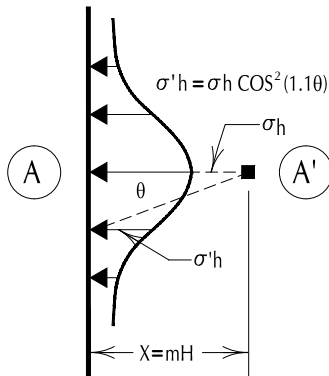
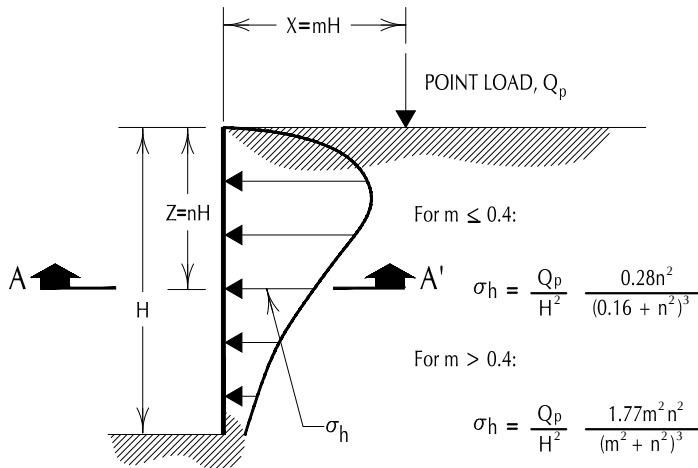
- 1) A VAPOR-RETARDING MEMBRANE SYSTEM IS RECOMMENDED FOR MOISTURE-SENSITIVE AREAS AND SHOULD BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
- 2) INTERNAL 4-IN.-DIAMETER PERFORATED DRAIN PIPES ARE TYPICALLY NOT NECESSARY IN THOSE AREAS WHERE THE FINISH FLOOR WILL BE ABOVE EXISTING SITE GRADES.



LINE LOAD PARALLEL TO WALL



STRIP LOAD PARALLEL TO WALL



DISTRIBUTION OF HORIZONTAL PRESSURES

VERTICAL POINT LOAD

NOTES:

1. THESE GUIDELINES APPLY TO RIGID WALLS WITH POISSON'S RATIO ASSUMED TO BE 0.5 FOR BACKFILL MATERIALS.
2. LATERAL PRESSURES FROM ANY COMBINATION OF ABOVE LOADS MAY BE DETERMINED BY THE PRINCIPLE OF SUPERPOSITION.



BEAVERTON SCHOOL DISTRICT
ARTS AND COMMUNICATIONS MAGNET ACADEMY

SURCHARGE-INDUCED LATERAL PRESSURE

APPENDIX A

Field Explorations and Laboratory Testing

APPENDIX A

FIELD EXPLORATIONS AND LABORATORY TESTING

FIELD EXPLORATIONS

General

Subsurface materials and conditions at the site were evaluated on May 29 and 30, 2018, with seven borings designated B-1 through B-7 and one cone penetration test (CPT) probe designated CPT-1. The approximate locations of the explorations completed for this project are shown on the Site Plan, Figure 2. The field exploration work was coordinated and documented by an engineering staff member from GRI, who maintained a log of the materials and conditions disclosed during the course of the work.

Borings

Borings B-1 through B-7 were advanced to depths of 5.5 to 41.5 ft with solid-stem auger drilling techniques using a trailer-mounted Buck Rogers 160 or Big Beaver portable drill rig provided and operated by Dan J. Fischer Excavating, Inc., of Forest Grove, Oregon. Disturbed and undisturbed samples were typically obtained from the borings at 2.5-ft intervals of depth in the upper 15 ft and at 5-ft intervals below this depth. Disturbed samples were obtained using a standard split-spoon sampler. At the time of sampling, the Standard Penetration Test (SPT) was conducted. This test consists of driving a standard split-spoon sampler into the soil a distance of 18 in. using a 140-lb hammer dropped 30 in. The number of blows required to drive the sampler the last 12 in. is known as the Standard Penetration Resistance, or SPT N-value. The SPT N-values provide a measure of the relative density of granular soils and the relative consistency of cohesive soils. The soil samples obtained in the split-spoon sampler were carefully examined in the field, and representative portions were saved in airtight jars for further examination and physical testing in our laboratory. Relatively undisturbed samples of fine-grained, cohesive soils were obtained by pushing 3-in.-outside-diameter (O.D.) Shelby tubes into the undisturbed soil a maximum distance of 24 in. using the drill rig. The soils exposed in the ends of the Shelby tubes were examined and classified in the field. After classification, the ends of the tubes were sealed with rubber caps and tape to preserve the natural moisture content of the soils. All samples were returned to our laboratory for further examination and testing.

Logs of the borings are provided on Figures 1A through 7A. Each log presents a descriptive summary of the various types of materials encountered in the boring and notes the depth at which the materials and/or characteristics of the materials change. To the right of the descriptive summary, the depth to groundwater and the numbers and types of samples are indicated. Farther to the right, SPT N-values are shown graphically, along with the natural moisture contents, Torvane shear strengths, percentage of material passing the No. 200 sieve, and Atterberg limits indices. Dry densities of undisturbed samples are shown in the far right column. The terms and symbols used to describe the soils encountered in the borings are defined in Table 1A and the attached legend.

Cone Penetration Test (CPT) Probe

The CPT probe, CPT-1, was advanced to a depth of about 71.5 ft below the ground surface using a truck-mounted, Dutch Cone Unit provided and operated by Oregon Geotechnical Explorations, Inc., of Keizer, Oregon. During the CPT, a steel cone is forced vertically into the soil at a constant rate of penetration. The force required to cause penetration can be related to the bearing capacity of the soil immediately surrounding

the point of the penetrometer cone. This force is measured and recorded every 2 in. In addition to the cone measurements, measurements are obtained of the magnitude of force required to force a friction sleeve, attached above the cone, through the soil. The force required to move the friction sleeve can be related to the undrained shear strength of fine-grained soils. The dimensionless ratio of sleeve friction to point bearing capacity provides an indicator of the type of soil penetrated. The cone penetration resistance and sleeve friction values can be used to evaluate the relative density and relative consistency of cohesionless and cohesive soils, respectively.

An accelerometer is also fitted at the end of the probe. The accelerometer is used to measure the arrival times of shear waves produced at the ground surface as the exploration is advanced. Using these measurements, the shear-wave velocity of the soils penetrated can be estimated. The shear-wave velocities characterize the soils for the purpose of seismic studies. Shear wave measurement was made at 3.28 or 6.56-ft (1- to 2-m) increments during advancement of CPT probe CPT-1. The results of the testing are tabulated below.

CPT-1 SHEAR WAVE VELOCITY MEASUREMENTS

Test Depth, ft	Shear-Wave Velocity, ft/second
6.56	602
9.84	467
13.12	542
16.40	602
19.69	898
22.97	969
26.25	862
29.53	1,169
32.81	1,081
36.09	1,017
39.37	1,084
42.65	827
45.93	1,032
49.21	1,268
52.49	910
55.77	1,060
59.06	997
62.34	1,949
65.62	2,704
68.90	3,645

The terms used to describe the soils encountered in the CPT probes are defined in Table 2A. A log of the CPT probe is provided on Figure 8A.

Infiltration Tests

Field infiltration tests were conducted in borings B-1, B-3, B-6, and B-7 on May 30, 2018, in general conformance with the City of Portland 2016 Stormwater Management Manual (SMM) using the encased falling head method. The tests consisted of advancing the borings to a depth of 5.5 ft and pushing a 6-in.-inside-diameter (I.D.), open-ended PVC pipe into the undisturbed soil. The pipe was generally embedded about 6 in. into the undisturbed soil. A height of about 1 ft of water was maintained in the pipe overnight to saturate the soil. After soaking, the drop in water level in the standpipe was recorded at 10-minute intervals for 1 hour. Three infiltration tests were conducted in each of the borings.

LABORATORY TESTING

General

All samples obtained from the field explorations were returned to our laboratory, where the physical characteristics of the samples were noted and the field classifications modified where necessary. At the time of classification, the natural moisture content of each sample was determined. Additional geotechnical laboratory testing included Atterberg limits determinations, Torvane shear strength measurements, dry unit weight determinations, and one-dimensional consolidation testing. Results of the geotechnical laboratory testing are summarized in Tables 3A. The following sections describe the testing program in more detail.

Natural Moisture Content

Natural moisture content determinations were made in conformance with ASTM International (ASTM) D2216. The results are provided on Figures 1A through 7A and in Table 3A.

Torvane Shear Strength

The approximate undrained shear strength of the fine-grained soils obtained in the Shelby tubes was determined using the Torvane shear device. The Torvane is a hand-held apparatus with vanes that are inserted into the soil. The torque required to fail the soil in shear around the vanes is measured using a calibrated spring. The results of the Torvane shear strength measurements are summarized on Figures 2A, 4A, and 5A.

Atterberg Limits

Atterberg limits (liquid limit, plastic limit, and plasticity index) determinations were performed on four representative samples of fine-grained soil in substantial conformance with ASTM D4318. The test results are summarized on Figures 2A, 4A, and 5A; the Plasticity Chart, Figure 9A; and in Table 3A.

Dry Unit Weight

The dry unit weight of selected undisturbed soil samples was determined in the laboratory in accordance with ASTM D2937 by cutting a cylindrical specimen of soil from a Shelby tube sample. The dimensions of the specimen were carefully measured, the volume calculated, and the specimen weighed. After oven-drying, the specimen was reweighed and the water content calculated. The dry unit weight was then computed. The dry unit weights are summarized on Figures 2A, 4A, and 5A, and in Table 3A.

One-Dimensional Consolidation

One-dimensional consolidation testing was performed on two relatively undisturbed fine-grained soil from the Shelby tubes in accordance with ASTM D2435 to obtain data on the compressibility characteristics and stress history of the soil. The results of the testing are summarized on Figures 10A and 11A in the form of a

curve showing effective stress versus percent strain. The initial moisture content and dry unit weight of each sample are provided on the figures.

Table 1A: GUIDELINES FOR CLASSIFICATION OF SOIL

Description of Relative Density for Granular Soil

Relative Density	Standard Penetration Resistance (N-values), blows per ft
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Description of Consistency for Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-values), blows per ft	Torvane or Undrained Shear Strength, tsf
Very Soft	0 - 2	less than 0.125
Soft	2 - 4	0.125 - 0.25
Medium Stiff	4 - 8	0.25 - 0.50
Stiff	8 - 15	0.50 - 1.0
Very Stiff	15 - 30	1.0 - 2.0
Hard	over 30	over 2.0

Grain-Size Classification

Modifier for Subclassification

		Primary Constituent SAND or GRAVEL	Primary Constituent SILT or CLAY
	Adjective	Percentage of Other Material (by weight)	
<i>Boulders:</i> > 12 in.			
<i>Cobbles:</i> 3 - 12 in.			
<i>Gravel:</i> 1/4 - 3/4 in. (fine)	trace:	5 - 15 (sand, gravel)	5 - 15 (sand, gravel)
3/4 - 3 in. (coarse)	some:	15 - 30 (sand, gravel)	15 - 30 (sand, gravel)
	sandy, gravelly:	30 - 50 (sand, gravel)	30 - 50 (sand, gravel)
<i>Sand:</i> No. 200 - No. 40 sieve (fine)	trace:	< 5 (silt, clay)	<i>Relationship of clay and silt determined by plasticity index test</i>
No. 40 - No. 10 sieve (medium)	some:	5 - 12 (silt, clay)	
No. 10 - No. 4 sieve (coarse)	silty, clayey:	12 - 50 (silt, clay)	
<i>Silt/Clay:</i> pass No. 200 sieve			

Table 2A: CONE PENETRATION TEST (CPT) CORRELATIONS

COHESIVE SOILS

Cone Tip Resistance, tsf	Consistency
< 5	Very Soft
5 to 15	Soft to Medium Stiff
15 to 30	Stiff
30 to 60	Very Stiff
> 60	Hard

COHESIONLESS SOILS

Cone Tip Resistance, tsf	Relative Density
< 20	Very Loose
20 to 40	Loose
40 to 120	Medium
120 to 200	Dense
> 200	Very Dense

Reference

Kulhawy, F. H., and Mayne, P. W., 1990, Manual on estimating soil properties for foundation design, Electric Power Research Institute, EL-6800.

Table 3A
SUMMARY OF LABORATORY RESULTS

Sample Information				Atterberg Limits					Soil Type
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	
B-1	S-1	2.5	--	26	--	--	--	--	FILL
	S-2	4.0	--	33	--	--	--	--	FILL
B-2	S-2	4.5	--	30	--	--	--	--	SILT
	S-3	7.5	--	34	--	--	--	--	SILT
	S-4	10.5	--	37	86	--	--	--	SILT
	S-5	12.0	--	41	--	--	--	97	SILT
	S-6	15.3	--	34	--	--	--	--	SILT
	S-6	15.7	--	29	97	--	--	--	SILT
	S-6	16.5	--	33	--	--	--	--	SILT
	S-7	17.0	--	34	--	27	7	--	SILT
	S-8	20.2	--	34	--	--	--	--	SILT
	S-8	21.2	--	40	--	--	--	--	SILT
	S-8	21.4	--	30	95	--	--	--	SILT
	S-9	22.0	--	25	--	47	30	--	CLAY
	S-10	25.5	--	23	106	--	--	--	CLAY
	S-10	26.1	--	23	--	--	--	--	CLAY
	S-11	26.5	--	23	--	--	--	--	CLAY
	S-13	31.5	--	22	--	--	--	--	CLAY
	S-14	35.3	--	28	101	--	--	--	CLAY
	S-15	35.7	--	35	--	--	--	--	CLAY
	S-16	40.0	--	25	--	--	--	--	CLAY
B-3	S-1	2.5	--	30	--	--	--	--	SILT
	S-2	4.0	--	34	--	--	--	--	SILT
B-4	S-1	2.5	--	33	--	--	--	--	SILT
	S-3	7.7	--	35	87	--	--	--	SILT
	S-4	9.0	--	38	--	32	6	--	SILT
	S-6	14.0	--	38	--	--	--	--	SILT
	S-8	18.3	--	33	--	--	--	--	SILT
	S-9	22.5	--	31	--	--	--	--	CLAY
	S-9	23.2	--	27	97	--	--	--	CLAY
	S-10	23.8	--	25	--	--	--	77	CLAY
	S-11	27.5	--	27	--	--	--	96	CLAY
	S-12	32.5	--	29	--	--	--	--	CLAY
	S-13	38.5	--	29	--	--	--	--	CLAY
B-5	S-2	4.3	--	31	--	--	--	--	SILT
	S-3	7.5	--	30	--	--	--	--	SILT
	S-4	10.0	--	35	--	--	--	85	SILT
	S-5	12.5	--	33	--	29	2	--	SILT
	S-7	17.5	--	34	--	--	--	--	SILT
	S-8	20.2	--	34	90	--	--	--	SILT

Table 3A
SUMMARY OF LABORATORY RESULTS

Sample Information				Atterberg Limits					Soil Type
Location	Sample	Depth, ft	Elevation, ft	Moisture Content, %	Dry Unit Weight, pcf	Liquid Limit, %	Plasticity Index, %	Fines Content, %	
B-5	S-9	20.8	--	33	--	--	--	92	CLAY
	S-10	25.0	--	25	--	--	--	--	CLAY
	S-11	30.0	--	25	--	--	--	94	CLAY
	S-12	35.0	--	27	--	--	--	--	CLAY
	S-13	40.0	--	23	--	--	--	--	CLAY
B-6	S-1	2.5	--	31	--	--	--	99	SILT
	S-2	4.0	--	32	--	--	--	--	SILT
B-7	S-1	2.5	--	28	--	--	--	--	SILT
	S-2	4.0	--	28	--	--	--	--	SILT

BORING AND TEST PIT LOG LEGEND

SOIL SYMBOLS

Symbol	Typical Description
	LANDSCAPE MATERIALS
	FILL
	GRAVEL; clean to some silt, clay, and sand
	Sandy GRAVEL; clean to some silt and clay
	Silty GRAVEL; up to some clay and sand
	Clayey GRAVEL; up to some silt and sand
	SAND; clean to some silt, clay, and gravel
	Gravelly SAND; clean to some silt and clay
	Silty SAND; up to some clay and gravel
	Clayey SAND; up to some silt and gravel
	SILT; up to some clay, sand, and gravel
	Gravelly SILT; up to some clay and sand
	Sandy SILT; up to some clay and gravel
	Clayey SILT; up to some sand and gravel
	CLAY; up to some silt, sand, and gravel
	Gravelly CLAY; up to some silt and sand
	Sandy CLAY; up to some silt and gravel
	Silty CLAY; up to some sand and gravel
	PEAT

BEDROCK SYMBOLS

Symbol	Typical Description
	BASALT
	MUDSTONE
	SILTSTONE
	SANDSTONE

SURFACE MATERIAL SYMBOLS

Symbol	Typical Description
	Asphalt concrete PAVEMENT
	Portland cement concrete PAVEMENT
	Crushed rock BASE COURSE

SAMPLER SYMBOLS

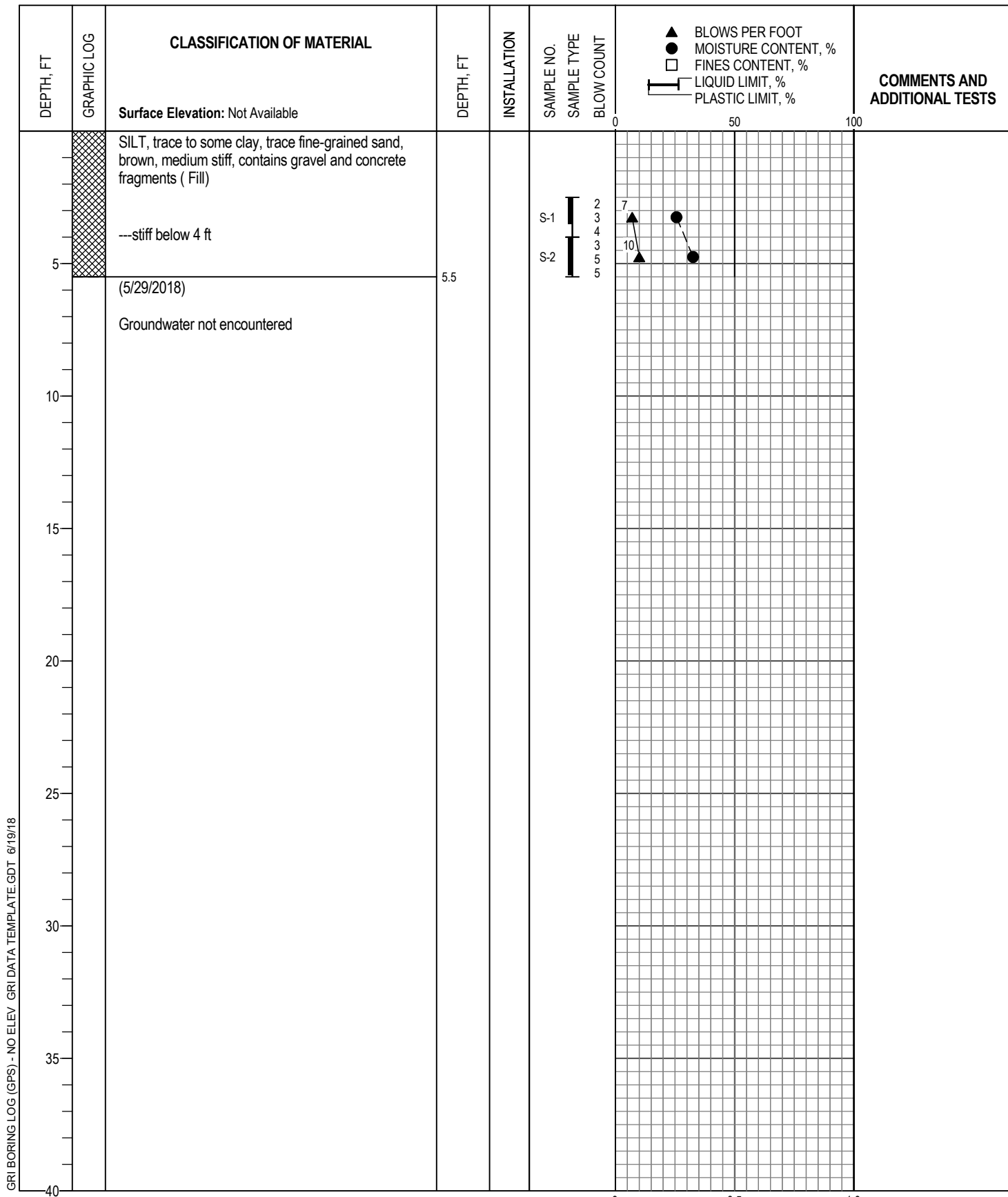
Symbol	Sampler Description
	2.0-in. O.D. split-spoon sampler and Standard Penetration Test with recovery (ASTM D1586)
	Shelby tube sampler with recovery (ASTM D1587)
	3.0-in. O.D. split-spoon sampler with recovery (ASTM D3550)
	Grab Sample
	Rock core sample interval
	Sonic core sample interval
	Geoprobe sample interval

INSTALLATION SYMBOLS

Symbol	Symbol Description
	Flush-mount monument set in concrete
	Concrete, well casing shown where applicable
	Bentonite seal, well casing shown where applicable
	Filter pack, machine-slotted well casing shown where applicable
	Grout, vibrating-wire transducer cable shown where applicable
	Vibrating-wire pressure transducer
	1-in.-diameter solid PVC
	1-in.-diameter hand-slotted PVC
	Grout, inclinometer casing shown where applicable

FIELD MEASUREMENTS

Symbol	Typical Description
	Groundwater level during drilling and date measured
	Groundwater level after drilling and date measured
	Rock core recovery (%)
	Rock quality designation (RQD, %)

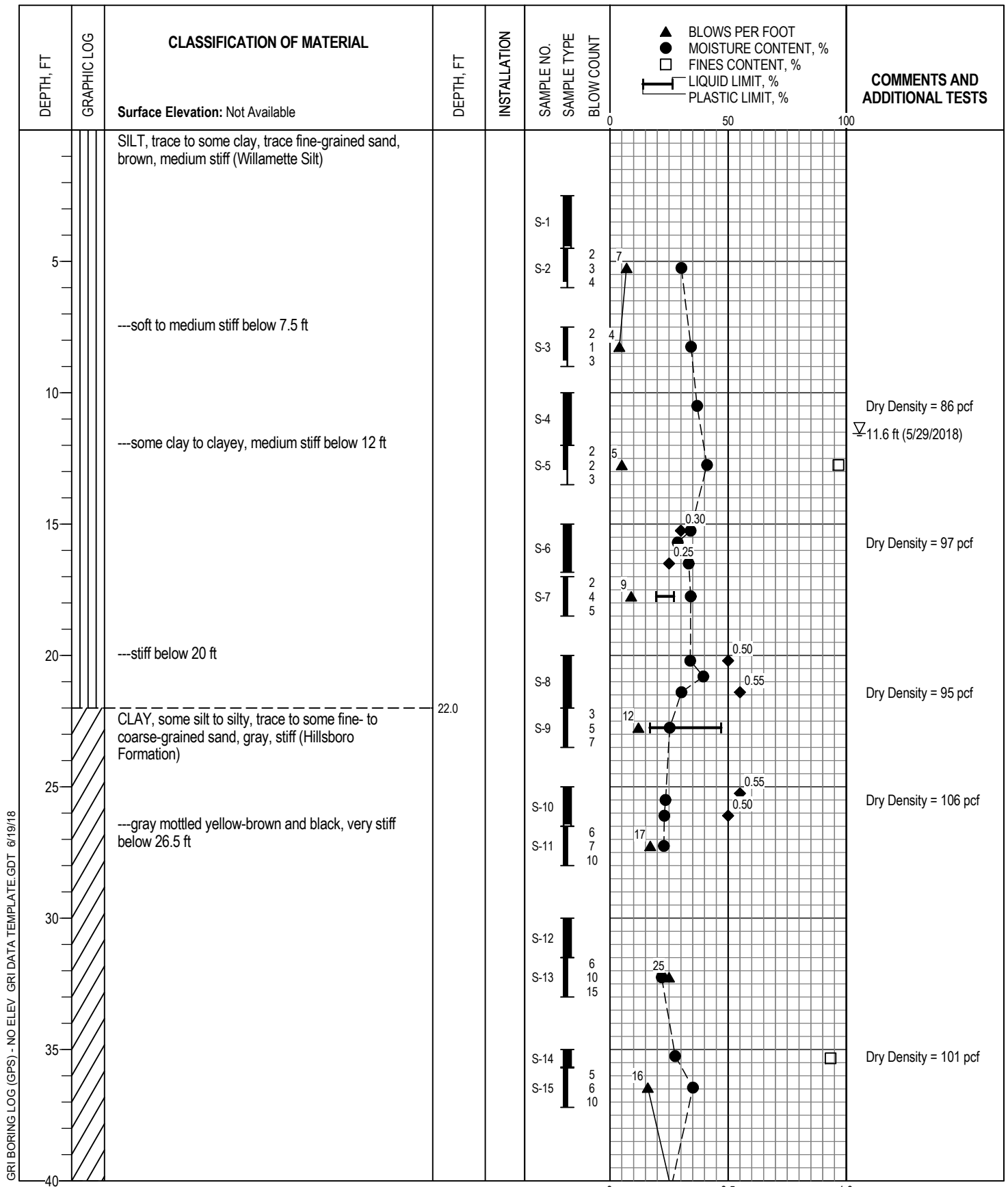


Logged By: N. Utevsky		Drilled by: Dan J. Fischer Excavating, Inc.	
Date Started: 5/29/18	GPS Coordinates: 45.49553° N -122.79413° W (WGS 84)		
Drilling Method: Solid-Stem Auger		Hammer Type: Manual	
Equipment: Buck Rogers 160 Trailer-Mounted Rig		Weight: 140 lb	
Hole Diameter: 8 in.		Drop: 30 in.	
Note: See Legend for Explanation of Symbols		Energy Ratio:	

- ◆ TORVANE SHEAR STRENGTH, TSF
 ■ UNDRAINED SHEAR STRENGTH, TSF



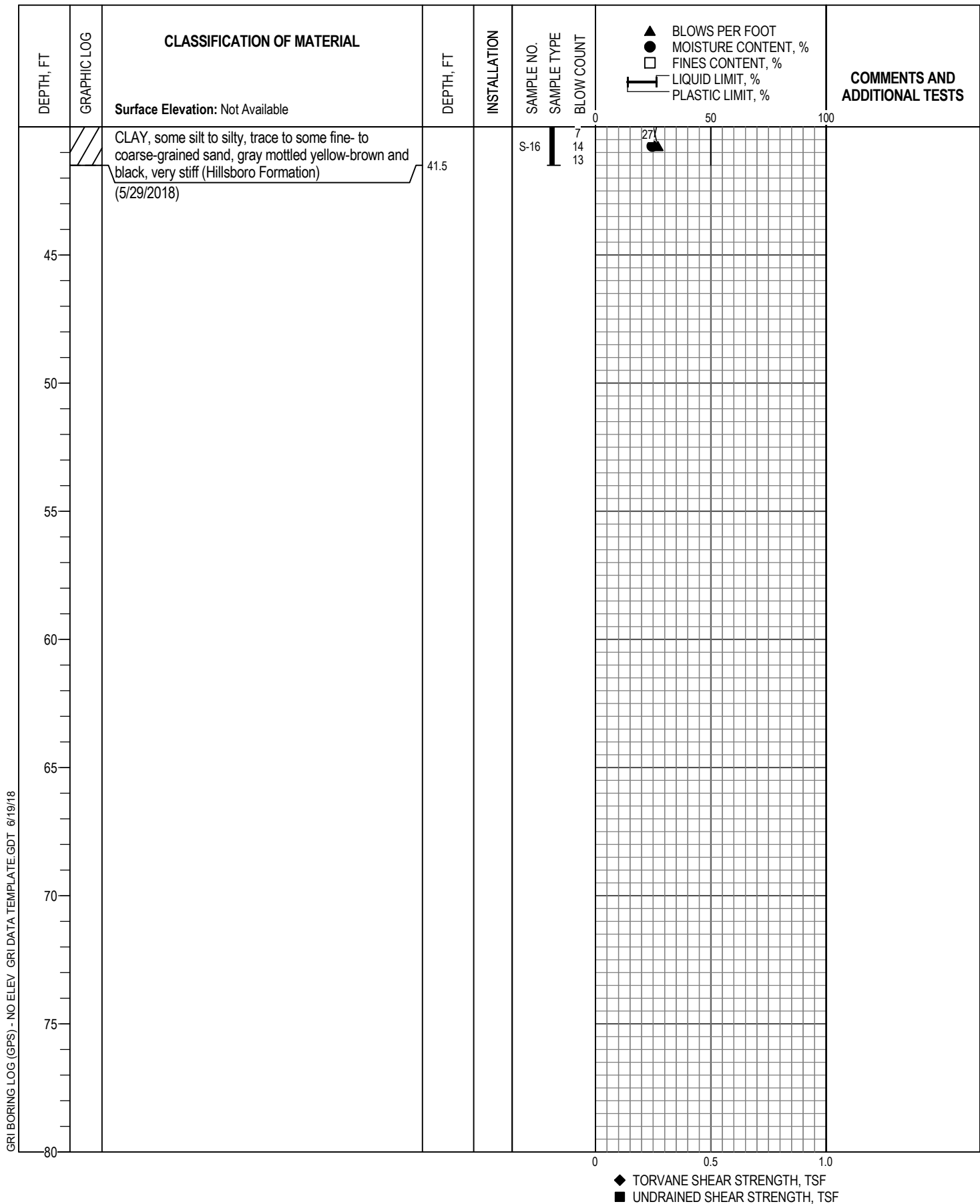
BORING B-1



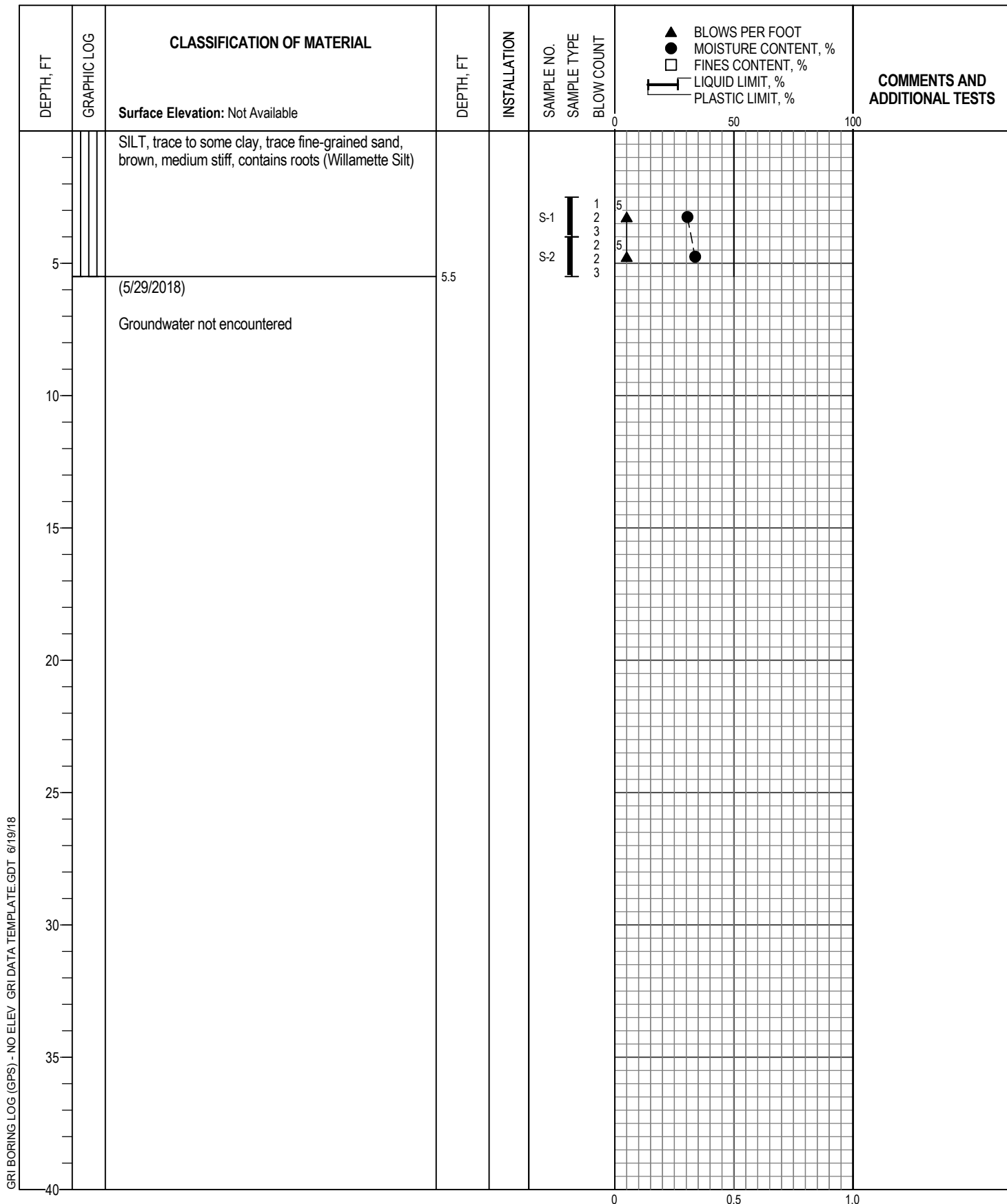
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Date Started: 5/29/18	GPS Coordinates: 45.49519° N -122.7941° W (WGS 84)
Drilling Method: Solid-Stem Auger	Hammer Type: Manual
Equipment: Buck Rogers 160 Trailer-Mounted Rig	Weight: 140 lb
Hole Diameter: 4 in.	Drop: 30 in.
Note: See Legend for Explanation of Symbols	Energy Ratio:



BORING B-2



BORING B-2

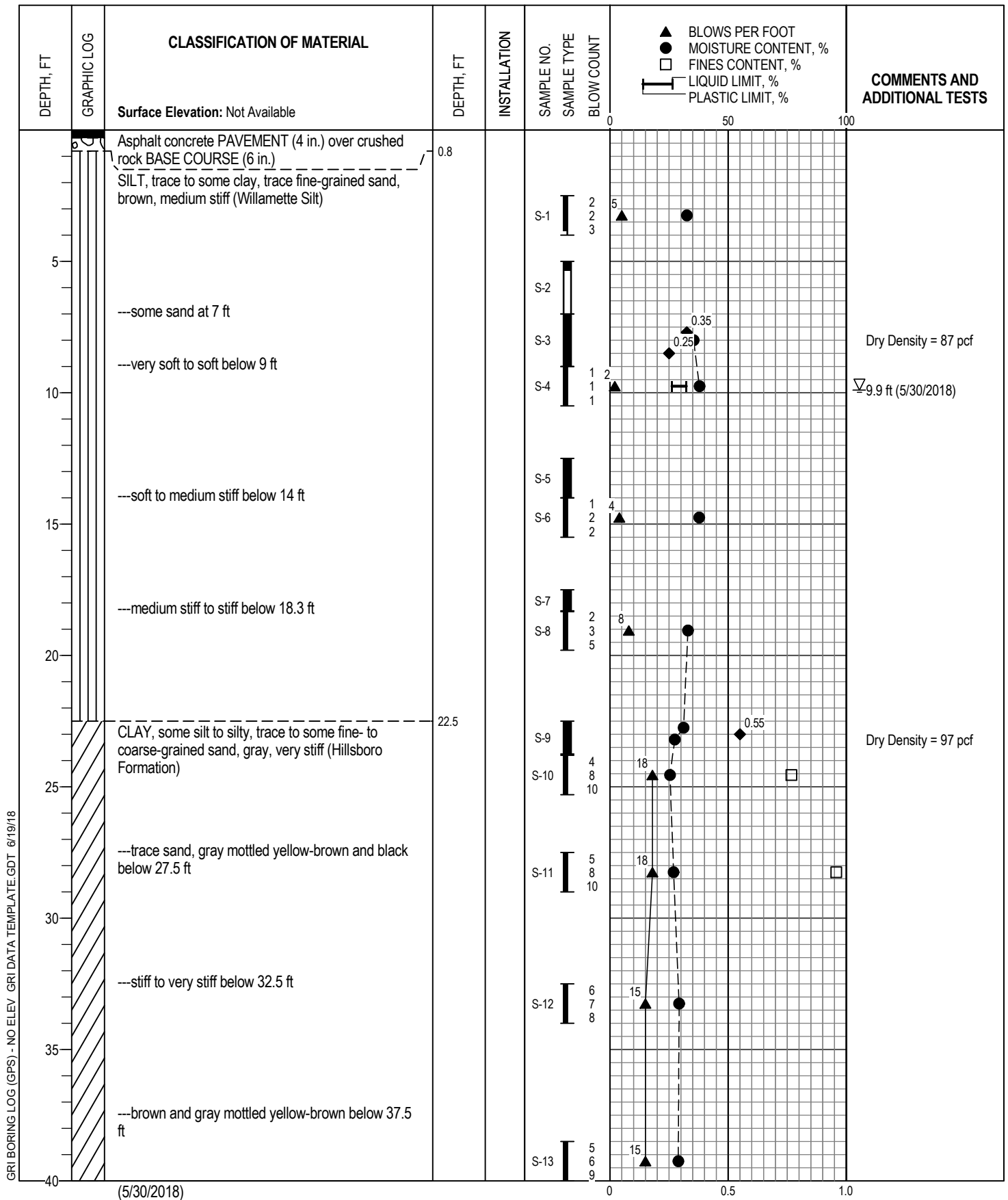


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Date Started: 5/29/18	GPS Coordinates: 45.49509° N -122.79349° W (WGS 84)		
Drilling Method: Solid-Stem Auger		Hammer Type: Manual	
Equipment: Big Beaver Portable Drill		Weight: 140 lb	
Hole Diameter: 8 in.		Drop: 30 in.	
Note: See Legend for Explanation of Symbols		Energy Ratio:	

- ◆ TORVANE SHEAR STRENGTH, TSF
- UNDRAINED SHEAR STRENGTH, TSF



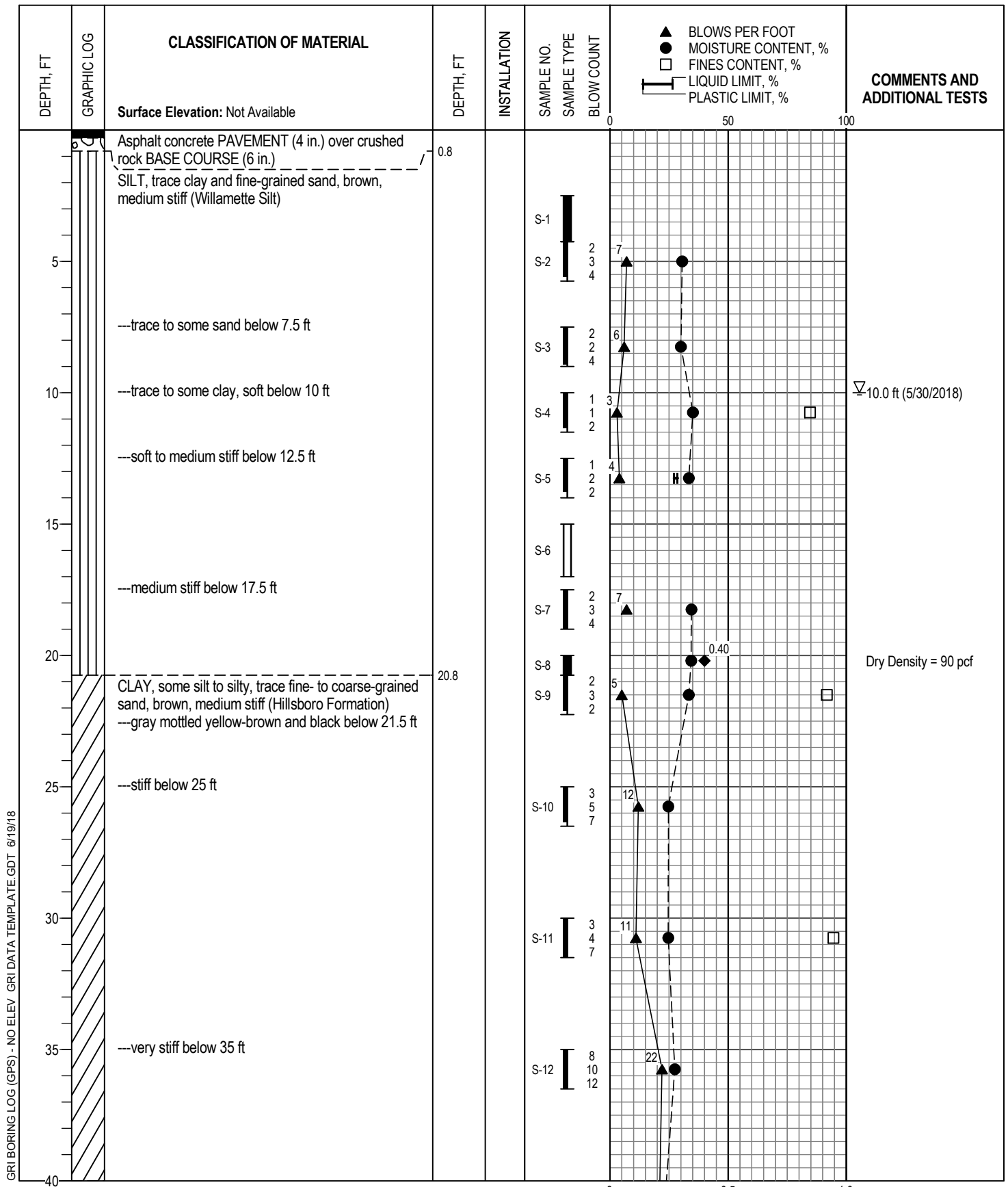
BORING B-3



Logged By: N. Utevsky		Drilled by: Dan J. Fischer Excavating, Inc.	
Date Started: 5/30/18	GPS Coordinates: 45.49473° N -122.79425° W (WGS 84)		
Drilling Method: Solid-Stem Auger		Hammer Type: Manual	
Equipment: Big Beaver Portable Drill		Weight: 140 lb	
Hole Diameter: 4 in.		Drop: 30 in.	
Note: See Legend for Explanation of Symbols		Energy Ratio:	



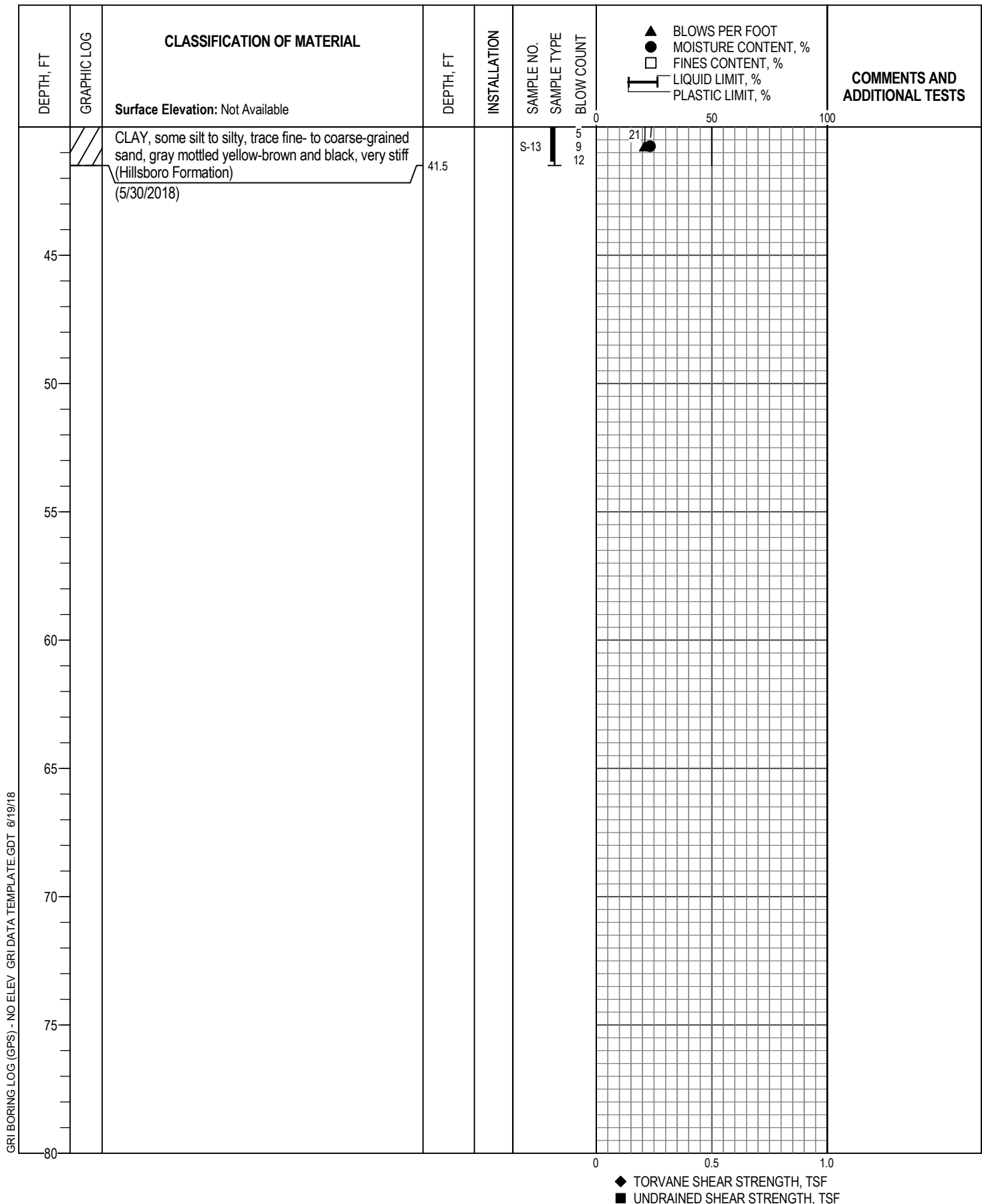
BORING B-4



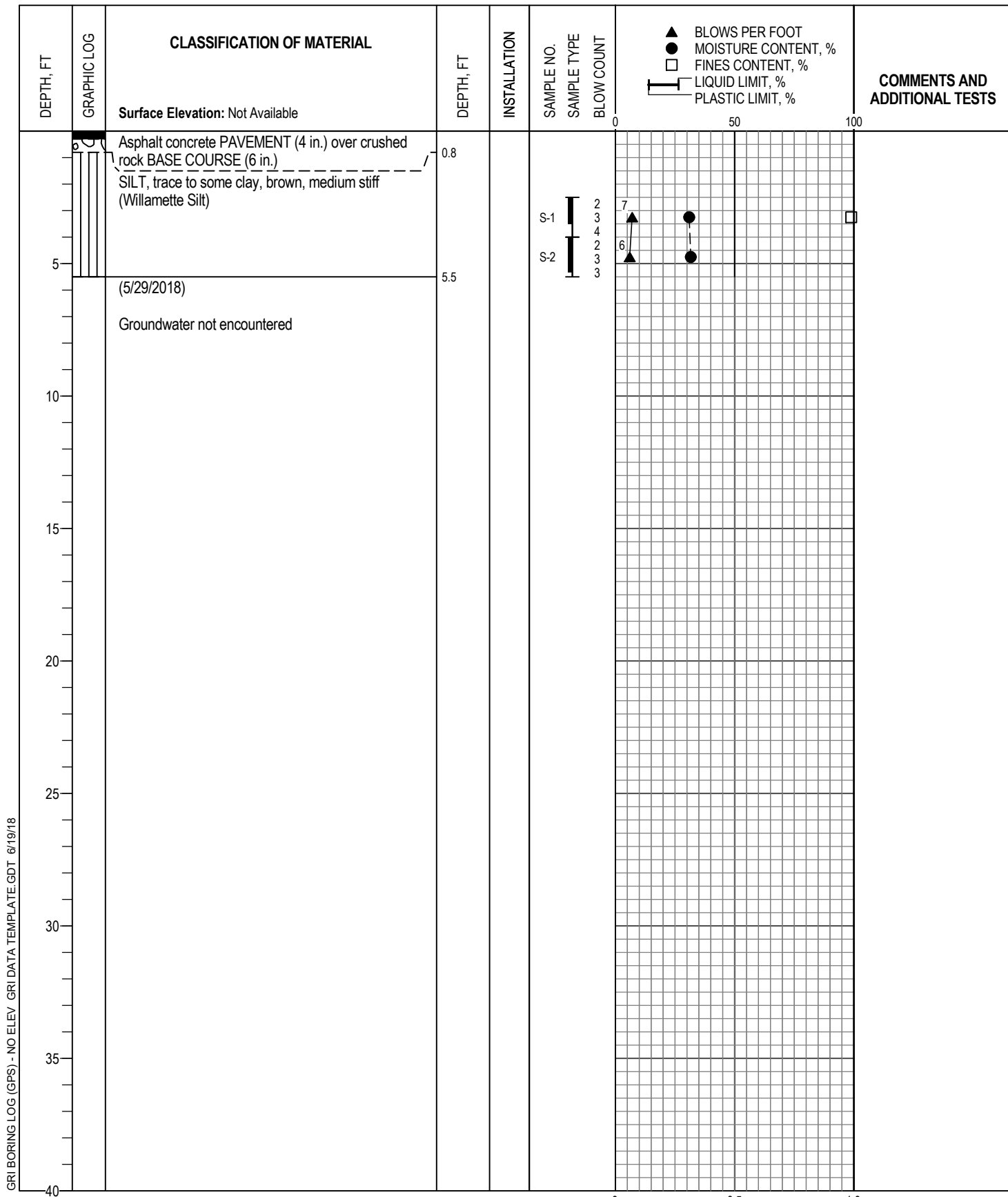
Logged By: N. Utevsy	Drilled by: Dan J. Fischer Excavating, Inc.
Date Started: 5/30/18	GPS Coordinates: 45.49445° N -122.79424° W (WGS 84)
Drilling Method: Solid-Stem Auger	Hammer Type: Manual
Equipment: Big Beaver Portable Drill	Weight: 140 lb
Hole Diameter: 4 in.	Drop: 30 in.
Note: See Legend for Explanation of Symbols	Energy Ratio:



BORING B-5



BORING B-5

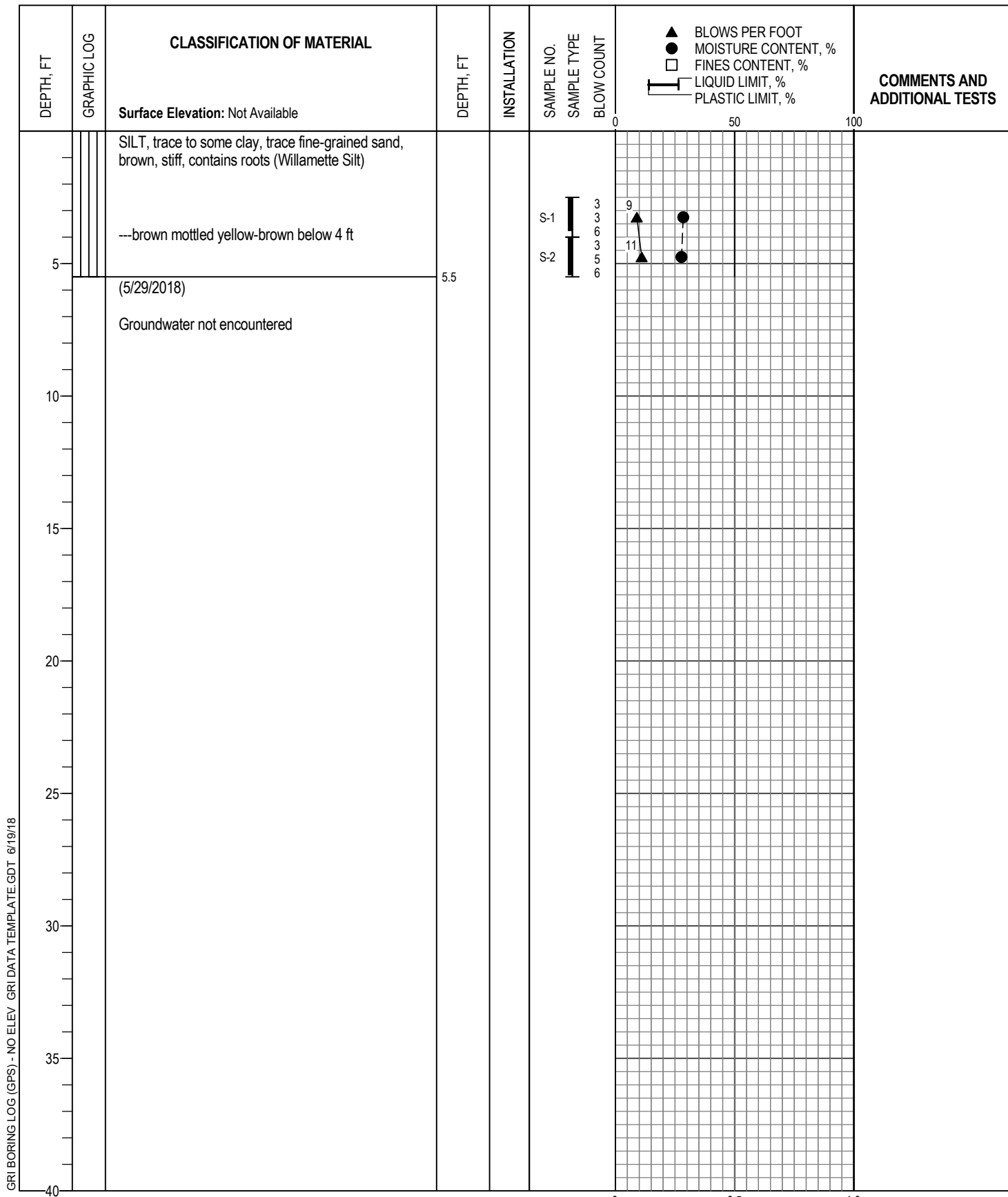


Logged By: N. Utevsy		Drilled by: Dan J. Fischer Excavating, Inc.	
Date Started: 5/29/18	GPS Coordinates: 45.49429° N -122.79353° W (WGS 84)		
Drilling Method: Solid-Stem Auger		Hammer Type: Manual Weight: 140 lb Drop: 30 in. Energy Ratio:	
Equipment: Big Beaver Portable Drill			
Hole Diameter: 8 in.			
Note: See Legend for Explanation of Symbols			

◆ TORVANE SHEAR STRENGTH, TSF
 ■ UNDRAINED SHEAR STRENGTH, TSF



BORING B-6

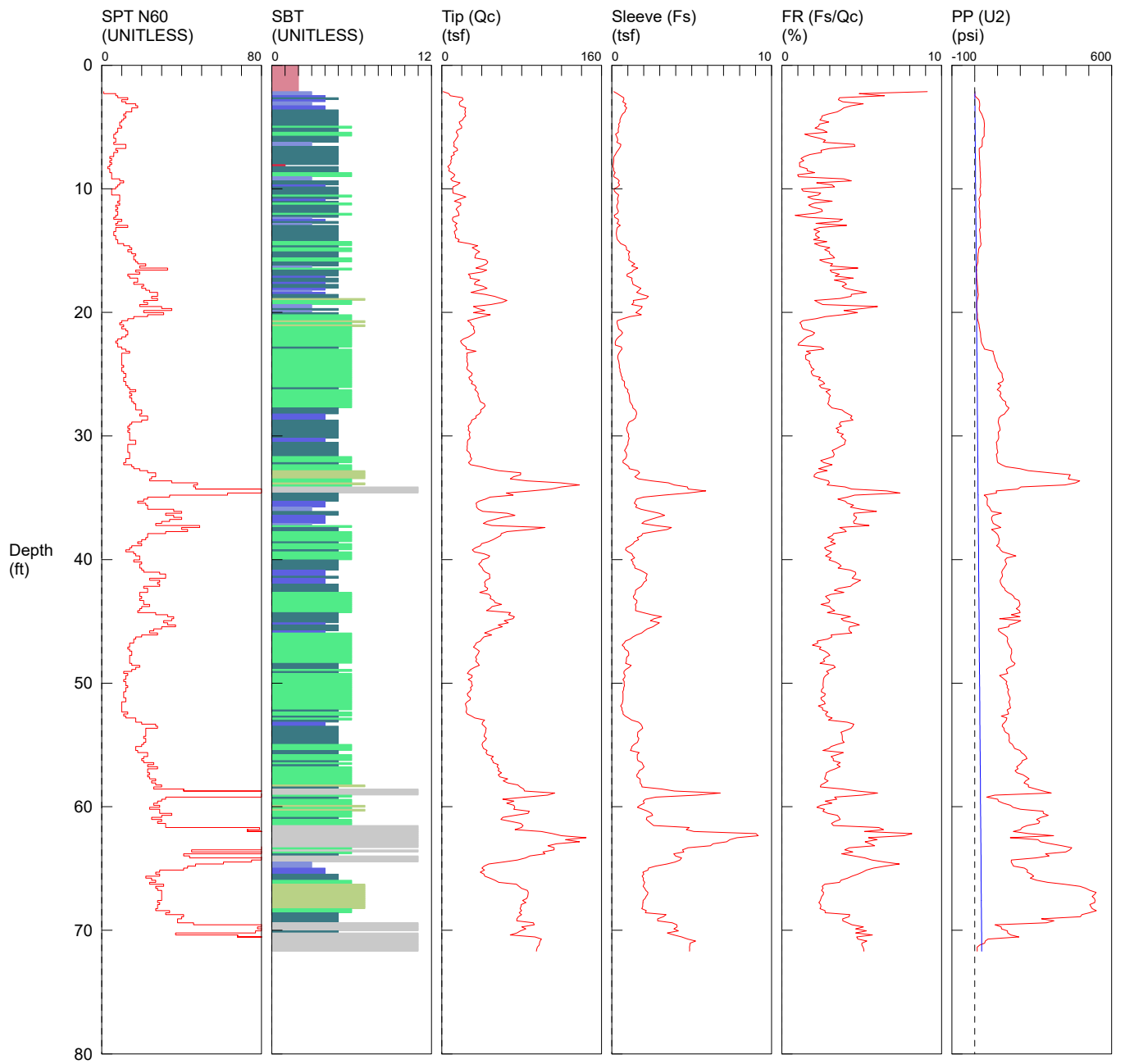


Logged By: N. Utevsy		Drilled by: Dan J. Fischer Excavating, Inc.	
Date Started: 5/29/18	GPS Coordinates: 45.49407° N -122.79417° W (WGS 84)		
Drilling Method: Solid-Stem Auger		Hammer Type: Manual	
Equipment: Big Beaver Portable Drill		Weight: 140 lb	
Hole Diameter: 8 in.		Drop: 30 in.	
Note: See Legend for Explanation of Symbols		Energy Ratio:	

- ◆ TORVANE SHEAR STRENGTH, TSF
- UNDRAINED SHEAR STRENGTH, TSF



BORING B-7



- | | | | |
|--------------------------|-----------------------------|----------------------------|--------------------------------|
| 1 sensitive fine grained | 4 silty clay to clay | 7 silty sand to sandy silt | 10 gravelly sand to sand |
| 2 organic material | 5 clayey silt to silty clay | 8 sand to silty sand | 11 very stiff fine grained (*) |
| 3 clay | 6 sandy silt to clayey silt | 9 sand | 12 sand to clayey sand (*) |
- *SBT/SPT CORRELATION: UBC-1983

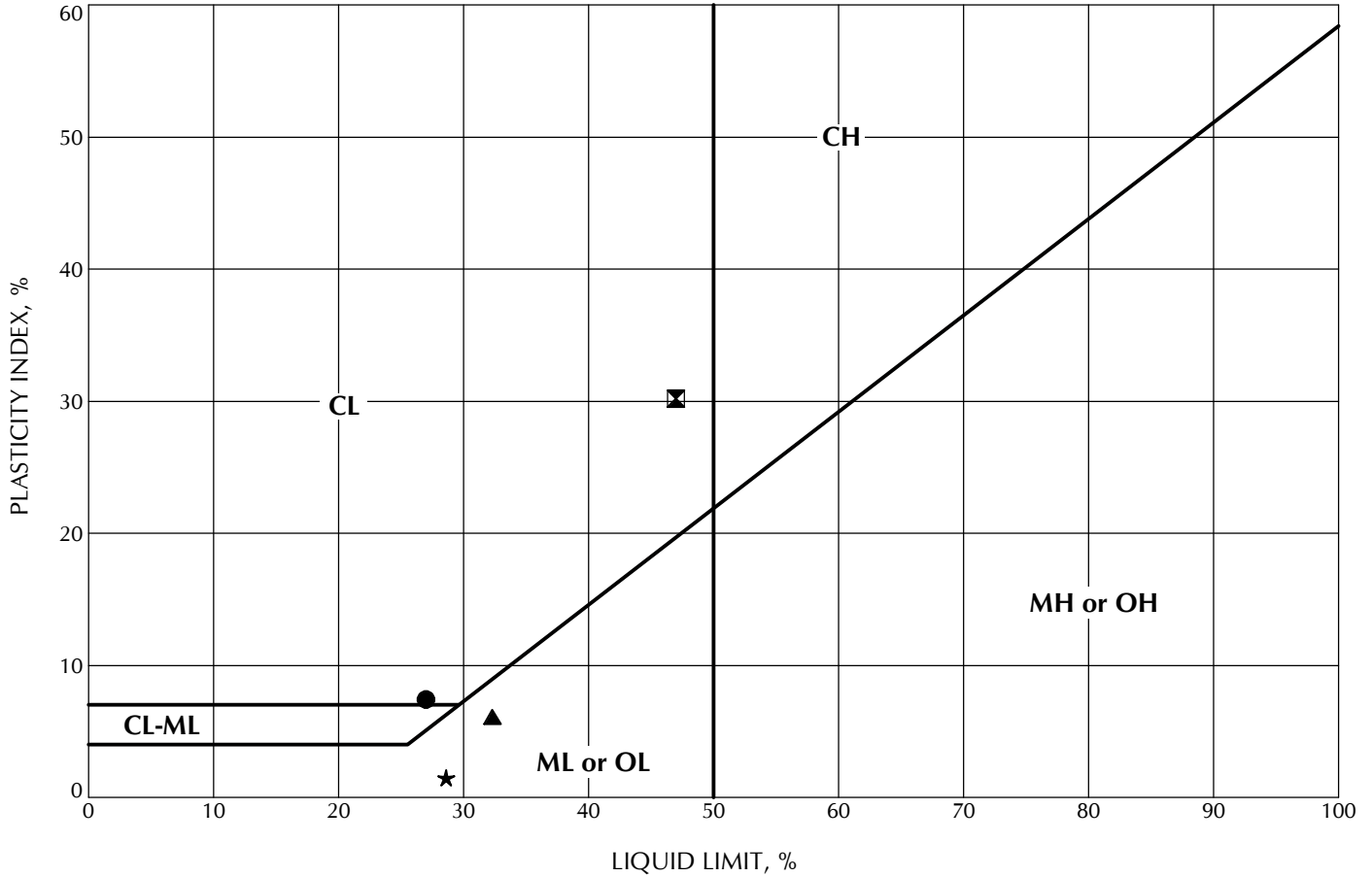


Observed By: N. Utevsy	Advanced By: Oregon Geotechnical Explorations, Inc.
Date Started: 05/30/18	Ground Surface Elevation: Not Available
Coordinates: Not Available	

CONE PENETRATION TEST CPT-1

GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
ML	INORGANIC CLAYEY SILTS TO VERY FINE SANDS OF SLIGHT PLASTICITY
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY

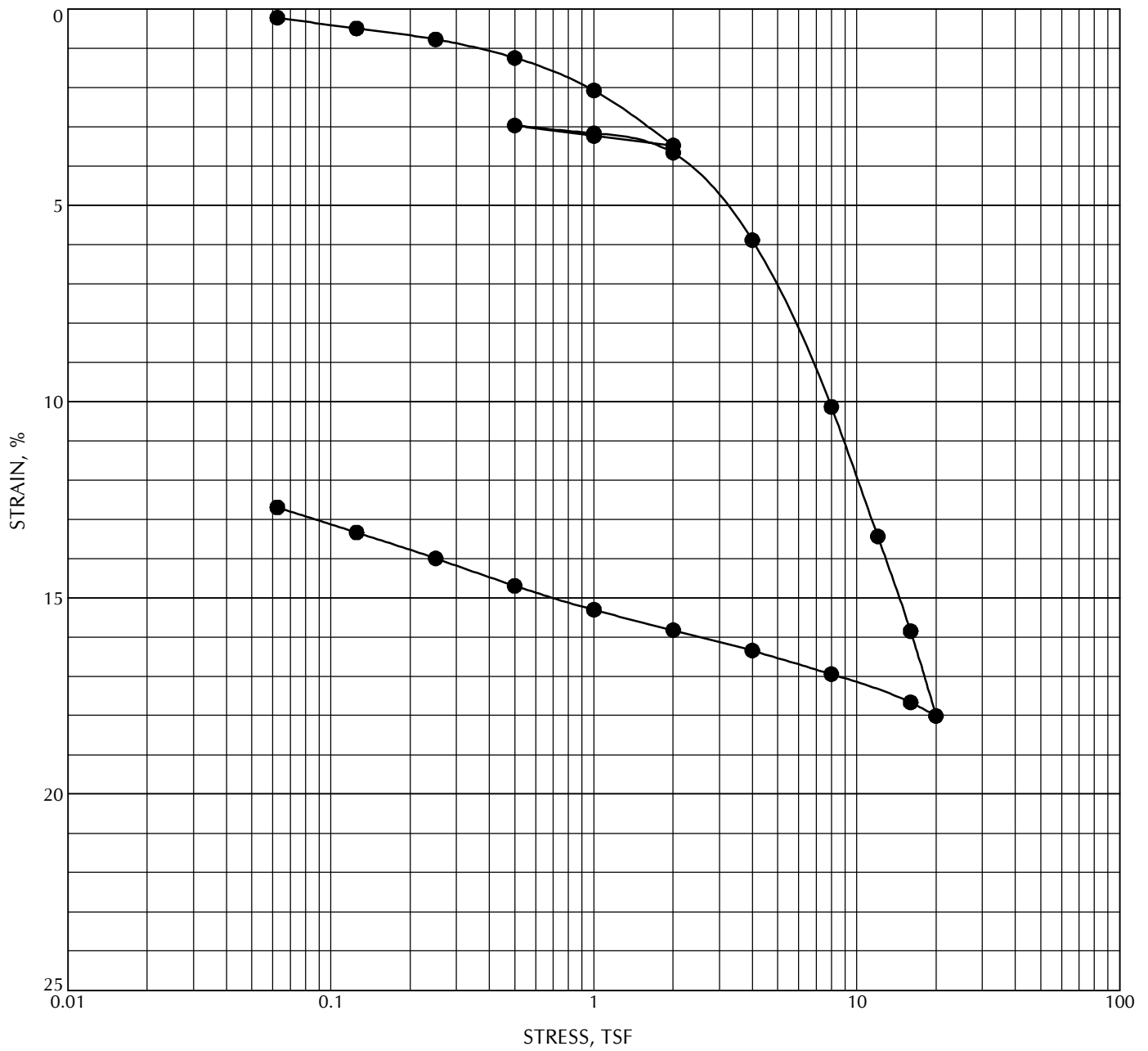
GROUP SYMBOL	UNIFIED SOIL CLASSIFICATION FINE-GRAINED SOIL GROUPS
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
MH	INORGANIC SILTS AND CLAYEY SILT
CH	INORGANIC CLAYS OF HIGH PLASTICITY



	Location	Sample	Depth, ft	Classification	LL	PL	PI	MC, %
●	B-2	S-7	17.0	Clayey SILT, trace fine-grained sand, brown (Willamette Silt)	27	20	7	34
⊠	B-2	S-9	22.0	CLAY, some silt to silty, trace to some fine- to coarse-grained sand, gray (Hillsboro Formation)	47	17	30	25
▲	B-4	S-4	9.0	SILT, trace to some clay, trace fine-grained sand, brown (Willamette Silt)	32	26	6	38
★	B-5	S-5	12.5	SILT, trace clay and fine-grained sand, brown (Willamette Silt)	29	27	2	33

GRI

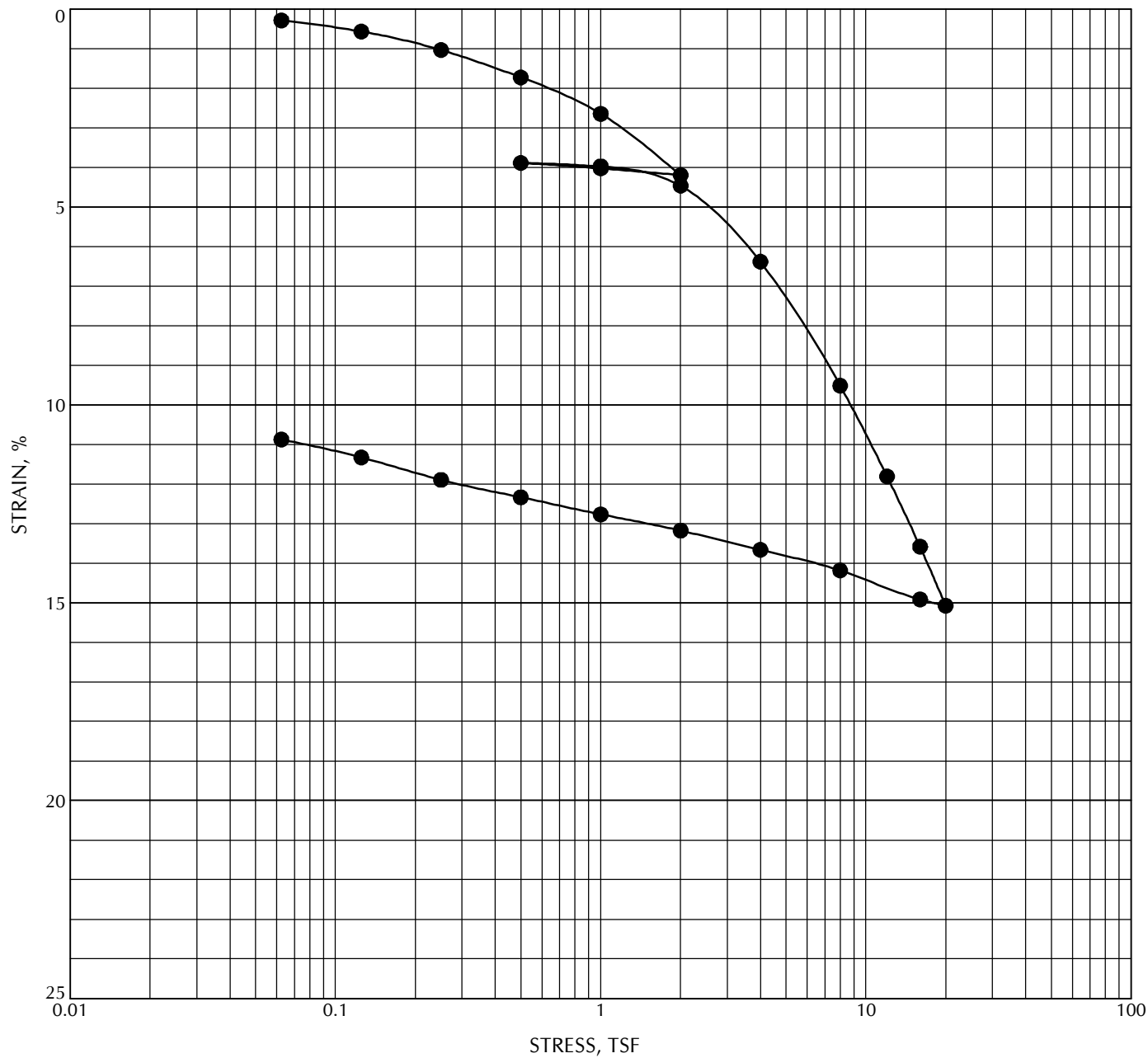
PLASTICITY CHART



					Initial	
Location	Sample	Depth, ft	Classification		γ_d , pcf	MC, %
● B-2	S-4	11.5	SILT, trace to some clay, trace fine-grained sand, brown, soft to medium stiff (Willamette Silt)		85	40



CONSOLIDATION TEST



					Initial	
Location	Sample	Depth, ft	Classification		γ_d , pcf	MC, %
● B-4	S-3	7.5	SILT, trace to some clay, trace fine-grained sand, brown, medium stiff (Willamette Silt)		91	33



CONSOLIDATION TEST

APPENDIX B

Site-Specific Seismic Hazard Study

APPENDIX B

SITE-SPECIFIC SEISMIC HAZARD STUDY

GENERAL

GRI completed a site-specific seismic hazard study for the proposed improvements to the Arts and Communications Magnet Academy (ACMA) in Beaverton, Oregon. The purpose of the study was to evaluate the potential seismic hazards associated with regional and local seismicity. We understand project improvements are being designed in accordance with the American Society of Civil Engineers (ASCE) Document 7-10, Minimum Design Loads for Buildings and Other Structures (ASCE 7-10), and 2014 Oregon Specialty Structural Code (OSSC). The ASCE 7-10 and 2014 OSSC require evaluation of seismic hazards based on the Risk-Targeted Maximum Considered Earthquake (MCE_R), which is defined in Chapter 21 of ASCE 7-10 as the response spectrum expected to achieve a 1% probability of building collapse within a 50-year period.

Our site-specific seismic hazard study was based on the potential for regional and local seismic activity, as described in the existing scientific literature, and on the subsurface conditions at the site, as disclosed by the geotechnical explorations completed for the project. Specifically, our work included the following tasks:

- 1) A detailed review of available literature, including published papers, maps, open-file reports, seismic histories and catalogs, and other sources of information regarding the tectonic setting, regional and local geology, and historical seismic activity that might have a significant effect on the site.
- 2) Compilation and evaluation of subsurface data gathered at and in the vicinity of the site, including classification and laboratory analyses of soil samples. This information was used to prepare a generalized subsurface profile for the site.
- 3) Identification of potential seismic sources appropriate for the site and characterization of those sources in terms of magnitude, distance, and acceleration response spectra.
- 4) Office studies, based on the generalized subsurface profile and the controlling seismic sources, resulting in conclusions and recommendations concerning:
 - a) specific seismic events and characteristic earthquakes that might have a significant effect on the project site,
 - b) the potential for seismic energy amplification at the site, and
 - c) site-specific acceleration response spectra for design of structures at the site.

This appendix describes the work accomplished and summarizes our conclusions and recommendations.

Geologic Setting

On a regional scale, the site is located at the northern end of the Willamette Valley lowland, a broad, gently deformed, north-south-trending topographic feature separating the Coast Range to the west from the Cascade Mountains to the east. The site is located approximately 81 km inland from the Cascadia Subduction Zone

(CSZ), an active plate boundary along which remnants of the Farallon Plate (the Gorda, Juan de Fuca, and Explorer plates) are being subducted beneath the western edge of the North American Plate. The subduction zone is a broad, eastward-dipping zone of contact between the upper portion of the subducting slabs of the Gorda, Juan de Fuca, and Explorer plates and the overriding North American Plate, as shown on the Tectonic Setting Summary, Figure 1B.

On a local scale, the site is located in the Portland Basin, a large, well-defined, northwest-trending structural basin bounded by high-angle, northwest-trending, right-lateral strike-slip faults considered to be seismogenic. The geologic units in the project area are shown on the Local Geologic Map, Figure 2B. The distribution of Quaternary faults in the site vicinity, as mapped by the U.S. Geological Survey (USGS), is shown on the Local Fault Map, Figure 3B. Information regarding the continuity and potential activity of these faults is lacking, due largely to the scale at which geologic mapping in the area has been conducted and the presence of thick, relatively young, basin-filling sediments that obscure underlying structural features. Other faults may be present within the project area, but clear stratigraphic and/or geophysical evidence regarding their location and extent is not presently available. Additional discussion regarding crustal faults is provided in the Local Crustal Event section below.

Because of the proximity of the site to the CSZ and its location within the Portland Basin, three distinctly different sources of seismic activity contribute to the potential for the occurrence of damaging earthquakes. Each of these sources is generally considered to be capable of producing damaging earthquakes. Two of these sources are associated with deep-seated tectonic activity related to the subduction zone; the third is associated with movement on the local, relatively shallow structures within and adjacent to the Portland Basin.

Subsurface Conditions. The project site is mantled with up to 22 ft of silt of the Willamette Silt Formation. The Willamette Silt soils are primarily brown and generally consist of silt with varying percentages of clay and fine-grained sand. The relative consistency of the Willamette Silt Formation is generally medium stiff to stiff. Soils of the Hillsboro Formation were encountered underlying the Willamette Silt Formation. The Hillsboro Formation generally consists of clay with variable silt and sand contents ranging from some silt to silty and trace to some fine- and coarse-grained sand. The clay is typically gray mottled yellow-brown and black. The relative consistency of the Hillsboro Formation is stiff to very stiff. Fill was encountered at the ground surface in boring B-1. The was brown and consisted of silt with trace to some clay and a trace of fine-grained sand. The relative consistency of the fill is generally medium stiff to stiff.

Seismicity

General. The available information indicates the potential seismic sources that may affect the site can be grouped into three independent categories: subduction zone events related to sudden slip between the upper surface of the Juan de Fuca Plate and the lower surface of the North American Plate, subcrustal (intraslab) events related to deformation and volume changes within the deeper portion of the subducted Juan de Fuca Plate, and local crustal events associated with movement on shallow local faults. Each of these sources is considered capable of producing damaging earthquakes in the Pacific Northwest. Based on review of historical records and evaluation of USGS national seismic hazard maps, the two primary types of seismic sources at the site are the megathrust CSZ and local crustal faults.

Cascadia Subduction Zone (CSZ). Written Japanese tsunami records suggest a great CSZ earthquake occurred in January of 1700 (Atwater et al., 2015). Geological studies suggest great megathrust earthquakes have occurred repeatedly in the past 7,000 years (Atwater et al., 1995; Clague, 1997; Goldfinger et al., 2003; and Kelsey et al., 2005), and geodetic studies (Hyndman and Wang, 1995; Savage et al., 2000) indicate rate of strain accumulation consistent with the assumption that the CSZ is locked beneath offshore northern California, Oregon, Washington, and southern British Columbia (Fluck et al., 1997; and Wang et al., 2001). Numerous geological and geophysical studies suggest the CSZ may be segmented (Hughes and Carr, 1980; Weaver and Michaelson, 1985; Guffanti and Weaver, 1988; Goldfinger, 1994; Kelsey and Bockheim, 1994; Mitchell et al., 1994; Personius, 1995; Nelson and Personius, 1996; and Witter, 1999), but the most recent studies suggest that for the last great earthquake in 1700, most of the subduction zone ruptured in a single Mw 9 earthquake (Satake et al., 1996; Atwater and Hemphill-Haley, 1997; and Clague et al., 2000). Published estimates of the probable maximum size of subduction zone events range from Mw 8.3 to >Mw 9. Numerous detailed studies of coastal subsidence, tsunamis, and turbidites yield a wide range of recurrence intervals, but the most complete records (>4,000 years) indicate intervals of about 350 to 600 years between great earthquakes on the CSZ (Adams, 1990; Atwater and Hemphill-Haley, 1997; Witter, 1999; Clague et al., 2000; Kelsey et al., 2002; Kelsey et al., 2005; and Witter et al., 2003). Tsunami inundation in buried marshes along the Washington and Oregon coast and stratigraphic evidence from the Cascadia margin support these recurrence intervals (Kelsey et al., 2005; and Goldfinger et al., 2003). Goldfinger et al. (2003, 2012) evaluated turbidite evidence for 20 earthquakes that ruptured the entire CSZ over the past 10,000 years and about 20 Mw 8 earthquakes that only ruptured along the southern portion of the CSZ and developed a model for recurrence of the CSZ Mw 8 to 9 earthquakes.

The USGS Probabilistic Seismic Hazard Analysis (PSHA) assumes four potential locations for the eastern edge of the earthquake rupture zone for the CSZ, as shown in Figure 4B. The 2008 USGS mapping effort indicates two rupture scenarios are assumed to represent these megathrust events: 1) Mw 9.0 ± 0.2 events that rupture the entire CSZ every 500 years, and 2) Mw 8.0 to 8.7 events with rupture zones that occur on segments of the CSZ and occur over the entire length of the CSZ during a period of about 500 years (Petersen et al., 2008). The assumed distribution of earthquake magnitudes is shown on Figure 5B. This distribution assumes the larger Mw 9.0 earthquake is the most likely single earthquake scenario on the CSZ.

Local Crustal Event. Sudden crustal movements along relatively shallow, local faults in the Portland area, although rare, have been responsible for local crustal earthquakes. The precise relationship between specific earthquakes and individual faults is not well understood, since few of the faults in the area are expressed at the ground surface and the foci of the observed earthquakes have not been located with precision. The history of local seismic activity is commonly used as a basis for determining the size and frequency to be expected of local crustal events. Although the historical record of local earthquakes is relatively short (the earliest reported seismic event in the area occurred in 1920), it can serve as a guide for estimating the potential for seismic activity in the area.

Based on fault mapping conducted by the USGS (Personius et al., 2003), the inferred location of the Portland Hills Fault is within 7 km of the site and is the closest crustal fault identified as a hazard to the site. The Portland Hills Fault has a characteristic earthquake magnitude of Mw 7.0. Based on Wong et al. (2001), the Portland Hills Fault is considered to be a reverse-oblique fault that dips to the southwest beneath the eastern base of the Portland Hills with a total fault length of approximately 40 to 60 km.

Code Background

As previously stated, seismic evaluation for the proposed improvements is being completed in accordance with the 2014 OSSC guideline, which references ASCE 7-10 and defines site-specific ground motions through MCE_R with the intent of including the probability of structural collapse. The code defines the site-specific MCE_R as the lower of the probabilistic MCE_R and the deterministic MCE_R . The ground motion associated with the probabilistic MCE_R represents a targeted risk level of 1% in 50 years probability of collapse in the direction of maximum horizontal response with 5% damping and is based on modifications to the USGS 2,475-year, hazard-level PSHA results. The deterministic MCE_R is the higher of the following: 1) an 84th-percentile, 5% damped spectral response in the direction of maximum horizontal response obtained from a characteristic earthquake on a known active fault within the region; or 2) the response spectrum from ASCE 7-10 Figure 21.2-1 with limiting spectral response factors, S_s and S_1 , of 1.5 and 0.6 g, respectively, and the site coefficients, F_a and F_v , factors based on the ASCE 7-10 soil site class.

Probabilistic and Deterministic Seismic Hazard Considerations

The probability of an earthquake of a specific magnitude occurring at a given location is commonly expressed by its return period, i.e., the average length of time between successive occurrences of an earthquake of that size or larger at that location. The return period of a design earthquake is calculated once a project design life and some measure of the acceptable risk that the design earthquake might occur or be exceeded are specified. These expected earthquake recurrences are expressed as a probability of exceedance (PE) during a given time period or design life. The USGS provides updated probabilistic seismic hazard maps about every six years for various PEs or hazard levels across the United States. The results of a PSHA for a given hazard level are commonly referred to as a Uniform Hazard Spectrum (UHS) because all spectral ordinates have a uniform PE in a given period of time.

The ASCE 7-10 and 2014 OSSC define probabilistic ground motions based on the MCE_R in Section 21.2.1 of ASCE 7-10. These codes utilize the 2008 USGS PSHA seismic hazard mapping effort. The probabilistic MCE_R is developed using the USGS PSHA 2% PE in 50 years (2,475-year recurrence interval) ground motions with the application of directivity factors and risk coefficients to the spectral values. The directivity factors adjust the spectral values from geometric mean to direction of maximum horizontal response and the risk coefficients incorporate the uniform collapse risk objective of 1% in a 50-year time period. The geometric mean ground motions provided by the USGS are converted to the corresponding direction of maximum horizontal response values by applying site-specific short- and long-period directivity factors obtained from the USGS Seismic Design Maps. Based on our review of the USGS maps, directivity factors of 1.1 and 1.3 were used to develop the maximum horizontal values at spectral periods less than or equal to 0.2 second and greater than or equal to 1.0 second, respectively. At spectral periods between 0.2 and 1.0 second, the directivity factor was estimated using linear interpolation. The risk coefficients used to convert the USGS ground motions to risk-targeted values are obtained from maps provided in Chapter 22 of ASCE 7-10. Based on our review of these maps, the short- and long-period risk coefficients (C_{RS}) and (C_{R1}) for the site are approximately 0.90 and 0.87, respectively. For other periods, the risk coefficients were estimated based on the method presented in Section 21.2.1.1 of ASCE 7-10. The method recommends applying C_{RS} at periods less than or equal to 0.2 second and C_{R1} at periods greater than or equal to 1.0 second. For periods between 0.2 and 1.0 second, the risk coefficients are based on linear interpolation. The probabilistic MCE_R values for the bedrock or B/C boundary condition at the site are summarized on Table 1B. For comparison purposes,

the table also includes the USGS 2% in 50-year spectral values. It should be noted that the probabilistic MCE_R and the 2,475-year hazard-level spectral values are relatively similar.

The probabilistic 2,475-year spectral value at zero period (PGA) represents the Maximum Considered Earthquake Geometric Mean (MCEG) peak ground accelerations defined by Section 21.5 of ASCE 7-10. The MCEG value is generally used for evaluating the potential for liquefaction, soil strength loss, and dynamic slope stability.

**Table 1B: 2008 USGS PSHA AND PROBABILISTIC MCE_R SPECTRAL VALUES
(SITE B/C BOUNDARY CONDITIONS)**

Period, seconds	Spectral Acceleration, g	
	2,475-Year*	Probabilistic MCE_R
0	0.44	0.44
0.1	0.92	0.91
0.2	1.01	1.00
0.3	0.87	0.88
0.5	0.68	0.71
1	0.38	0.43
2	0.19	0.22

* PSHA values obtained directly from 2008 USGS UHS.

A deterministic seismic hazard analysis (DSHA) was completed concurrently with review of the probabilistic analysis to evaluate the MCE_R in accordance with Section 21.2.2 of ASCE 7-10. The deterministic MCE_R ground motions are defined based on 84th percentile, i.e., one standard deviation, of the median spectral response acceleration in the direction of maximum horizontal response.

A DSHA is completed by estimating ground motions for characteristic magnitude earthquakes at the locations of active seismic sources in the region. Deaggregation of the 2008 USGS PSHA indicates the two primary seismic sources for the site are a magnitude M_w 9.0 CSZ earthquake with a source-to-site distance of approximately 81 km and a magnitude M_w 7.0 local crustal earthquake with a source-to-site distance of approximately 7 km. In accordance with assumptions for the 2008 USGS mapping effort incorporated in ASCE 7-10, the Ground Motion Prediction Equations (GMPE) of Youngs et al. (1997), Atkinson and Boore (2003), and Zhao et al. (2006), with weights of 0.25, 0.25, and 0.5, respectively, were used to develop the deterministic 84th-percentile response spectrum for the CSZ earthquakes. For the local crustal earthquakes, the GMPEs of Boore and Atkinson (2008), Campbell and Bozorgnia (2008), and Chiou and Youngs (2008) were used with equal weights to develop the deterministic 84th-percentile response spectrum. The deterministic 84th-percentile spectral values were then modified with the previously discussed directivity factors to obtain the spectral values in direction of maximum horizontal response. The resulting deterministic response spectra for bedrock or B/C boundary conditions are shown on Figure 6B.

Finally, the spectral values from the site-specific, 84th-percentile deterministic spectra were compared with the code-based deterministic lower limit spectrum provided in Section 21.2.2 of ASCE 7-10. The deterministic MCE_R spectrum is defined as the larger of the 84th-percentile spectral values and the code-

based lower limit. As shown on Figure 6B, the code-based lower limit deterministic spectrum was observed to be higher than both the local crustal-based 84th-percentile and the CSZ-based 84th-percentile deterministic spectra at all periods. Therefore, the deterministic MCE_R is defined by the code-based lower limit deterministic spectrum as defined in Section 21.2.2 of ASCE 7-10.

The MCE_R response spectrum is developed in accordance with the requirements of ASCE 7-10, which defines the controlling spectrum as the lower of the probabilistic MCE_R and the deterministic MCE_R spectra. Figure 7B shows a comparison of the probabilistic and deterministic MCE_R spectra and indicates the probabilistic spectral values are lower than the deterministic values at all periods. Therefore, in accordance with Section 21.2.3 of ASCE 7-10, the probabilistic MCE_R spectrum defines the MCE_R response spectrum.

Recommended Design Spectra

The recommended ground surface spectra were developed using the mapped bedrock spectral acceleration parameters S_s and S_1 at the site, and corresponding site amplification coefficients F_a and F_v to account for underlying soil conditions at the site. In accordance with Section 20.4.2 of ASCE 7-10 and the results of our subsurface investigation indicates the site is classified as Site Class D. For MCE_R hazard level, the S_s and S_1 spectral parameters corresponding to periods of 0.2 and 1.0 second are 1.00 and 0.43 g, respectively. The site coefficients, F_a and F_v , of 1.10 and 1.57, respectively, were applied in developing the ground surface MCE_R response spectrum. The design-level response spectrum is calculated as two-thirds of the MCE_R response spectrum. The spectral values are based on a damping ratio of 5%. The recommended ground surface response spectral values are summarized in Table 2B and on Figure 8B.

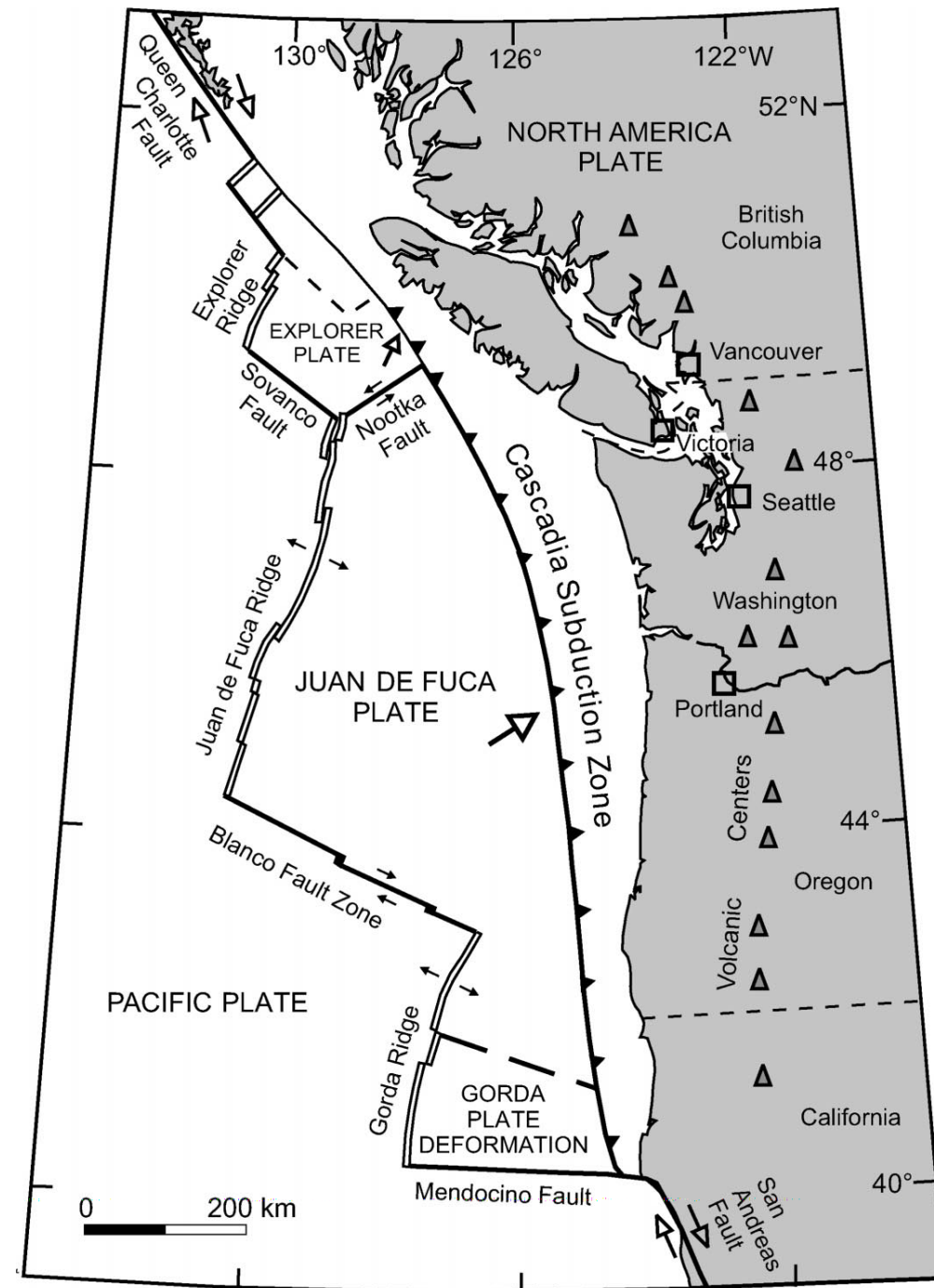
TABLE 2B: RECOMMENDED RESPONSE SPECTRA, 5% DAMPING

Period, seconds	MCE_R Spectral Values, g	Design Response Spectral Values, g
0.00	0.44	0.29
0.12	1.10	0.73
0.20	1.10	0.73
0.50	1.10	0.73
0.62	1.10	0.73
0.80	0.85	0.57
1.00	0.68	0.45
1.50	0.45	0.30
2.00	0.34	0.23
2.50	0.27	0.18
3.00	0.23	0.15

References

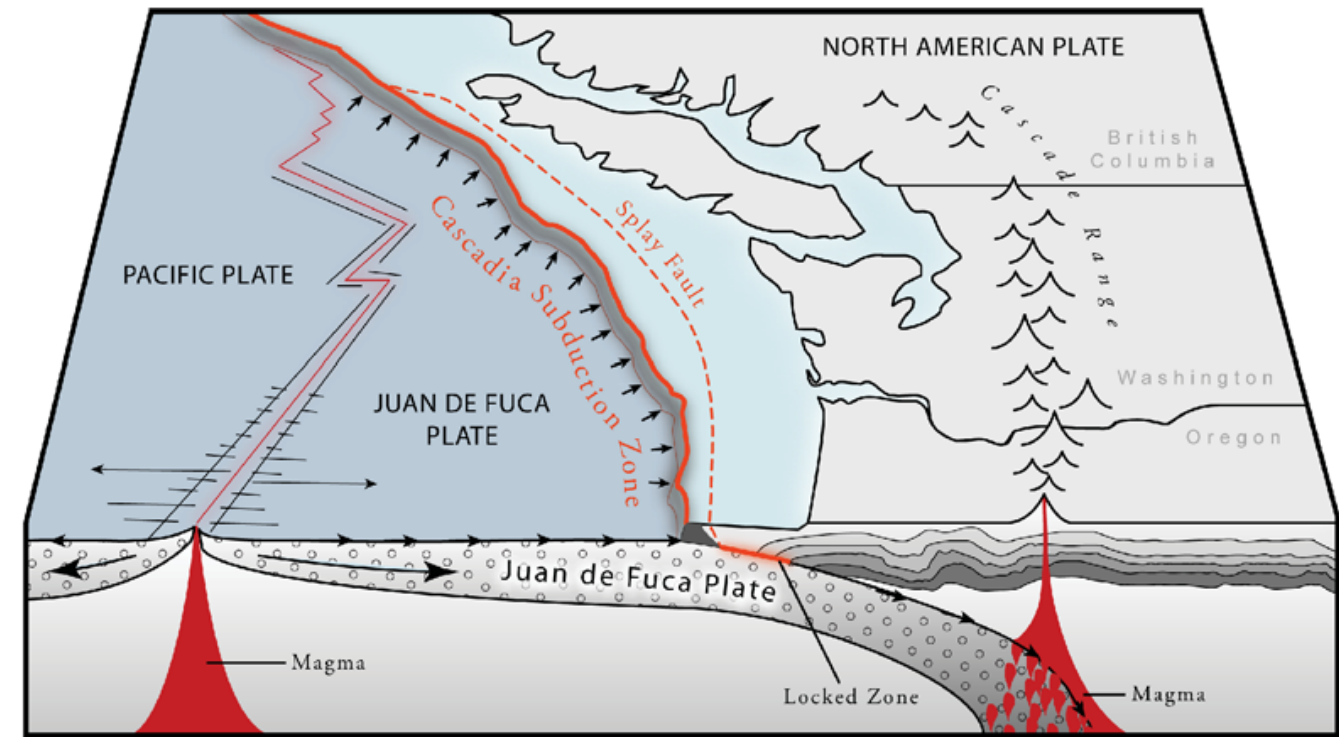
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A) TECTONIC MAP OF PACIFIC NORTHWEST, SHOWING ORIENTATION AND EXTENT OF CASCADIA SUBDUCTION ZONE (MODIFIED FROM DRAGERT AND OTHERS, 1994)

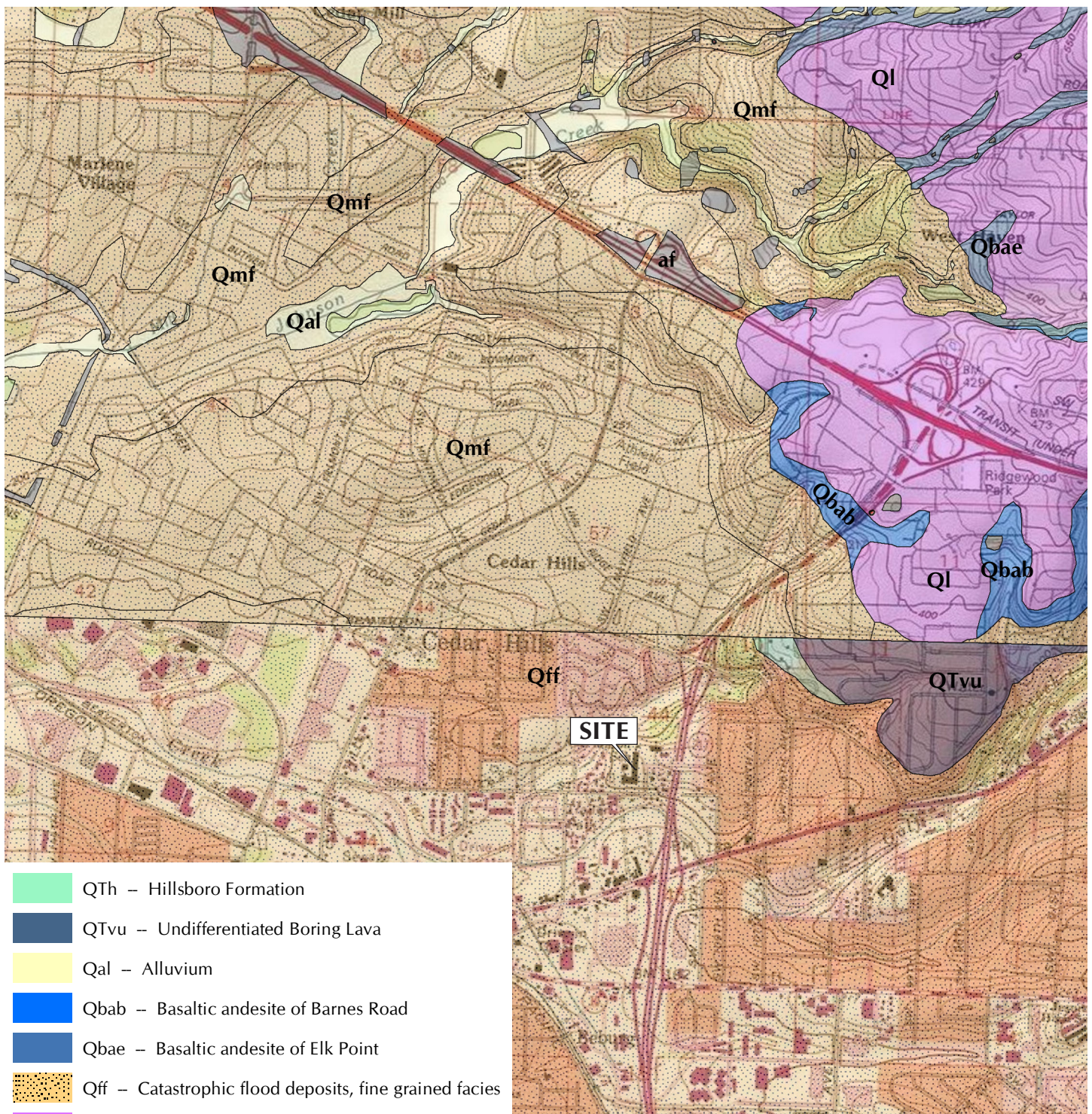
Cascadia Subduction Zone Setting



CASCADIA SUBDUCTION ZONE SETTING, TSUNAMI INUNDATION MAPS, OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRY, 2013



TECTONIC SETTING SUMMARY



- QTh – Hillsboro Formation
- QTvu – Undifferentiated Boring Lava
- Qal – Alluvium
- Qbab – Basaltic andesite of Barnes Road
- Qbae – Basaltic andesite of Elk Point
- Qff – Catastrophic flood deposits, fine grained facies
- Ql – Primary Loess
- Qls2 – Surficial landslides
- Qmf – Missoula Flood Deposits
- Qt – terrace deposits
- af – Artificial fill
- reservoir --



0 2,000 4,000 FT

GRI

LOCAL GEOLOGIC MAP

Modified from: Oregon Department of Geology
and Mineral Industries Digital Data Series OGDC-6

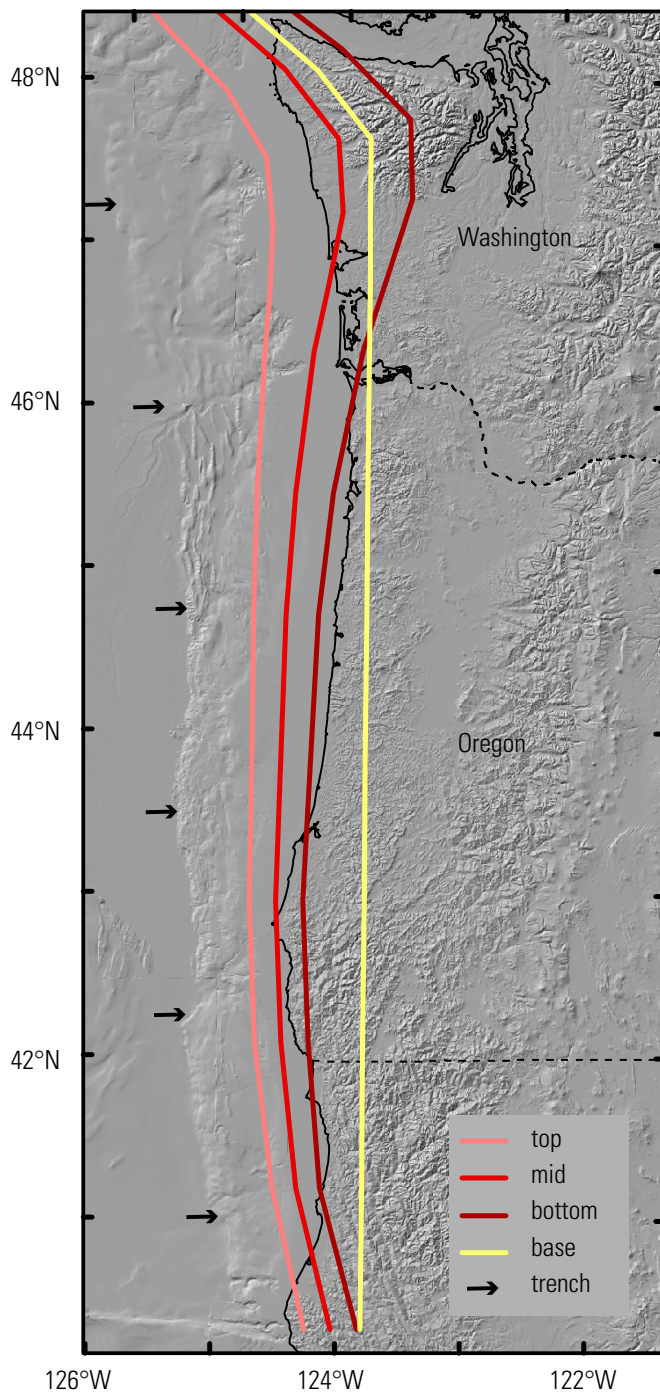


FIGURE 21. LOCATION OF THE EASTERN EDGE OF EARTHQUAKE RUPTURE ZONES ON THE CASCADIA SUBDUCTION ZONE FOR THE VARIOUS MODELS USED IN THIS STUDY RELATIVE TO THE SURFICIAL EXPRESSION OF THE TRENCH: TOP, BASE OF THE ELASTIC ZONE; MID, MIDPOINT OF THE TRANSITION ZONE; BOTTOM, BASE OF THE TRANSITION ZONES; BASE, BASE OF THE MODEL THAT ASSUMES RUPTURES EXTEND TO ABOUT 30-KILOMETERS DEPTH. FIGURE PROVIDED BY RAY WELDON.

FROM: PETERSEN, MD, FRANKEL, AD, HARMSSEN, SC, AND OTHERS, 2008, DOCUMENTATION FOR THE 2008 UPDATE OF THE UNITED STATES NATIONAL SEISMIC HAZARD MAPS: US GEOLOGICAL SURVEY, OPEN FILE REPORT 2008-1128



ASSUMED RUPTURE LOCATIONS (CASCADIA SUBDUCTION ZONE)

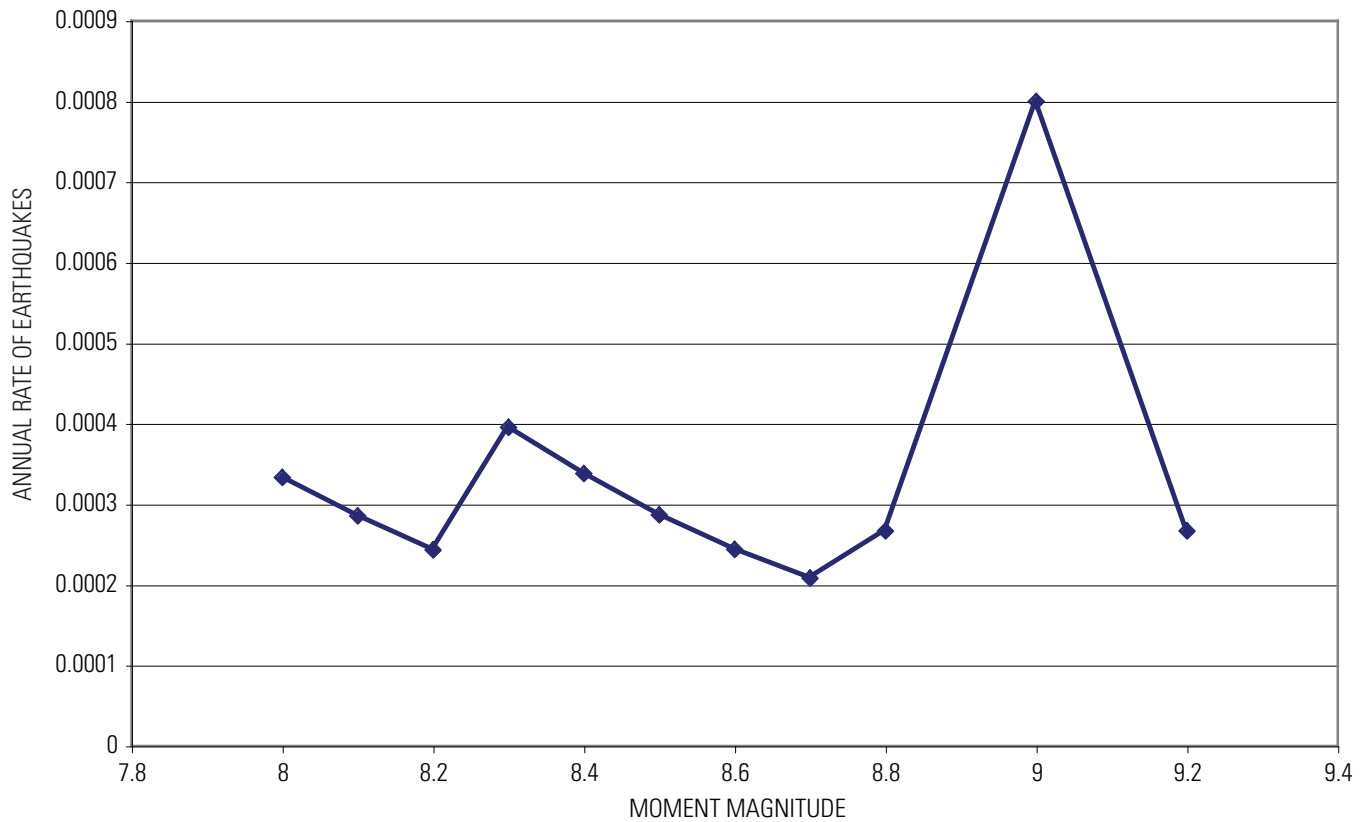
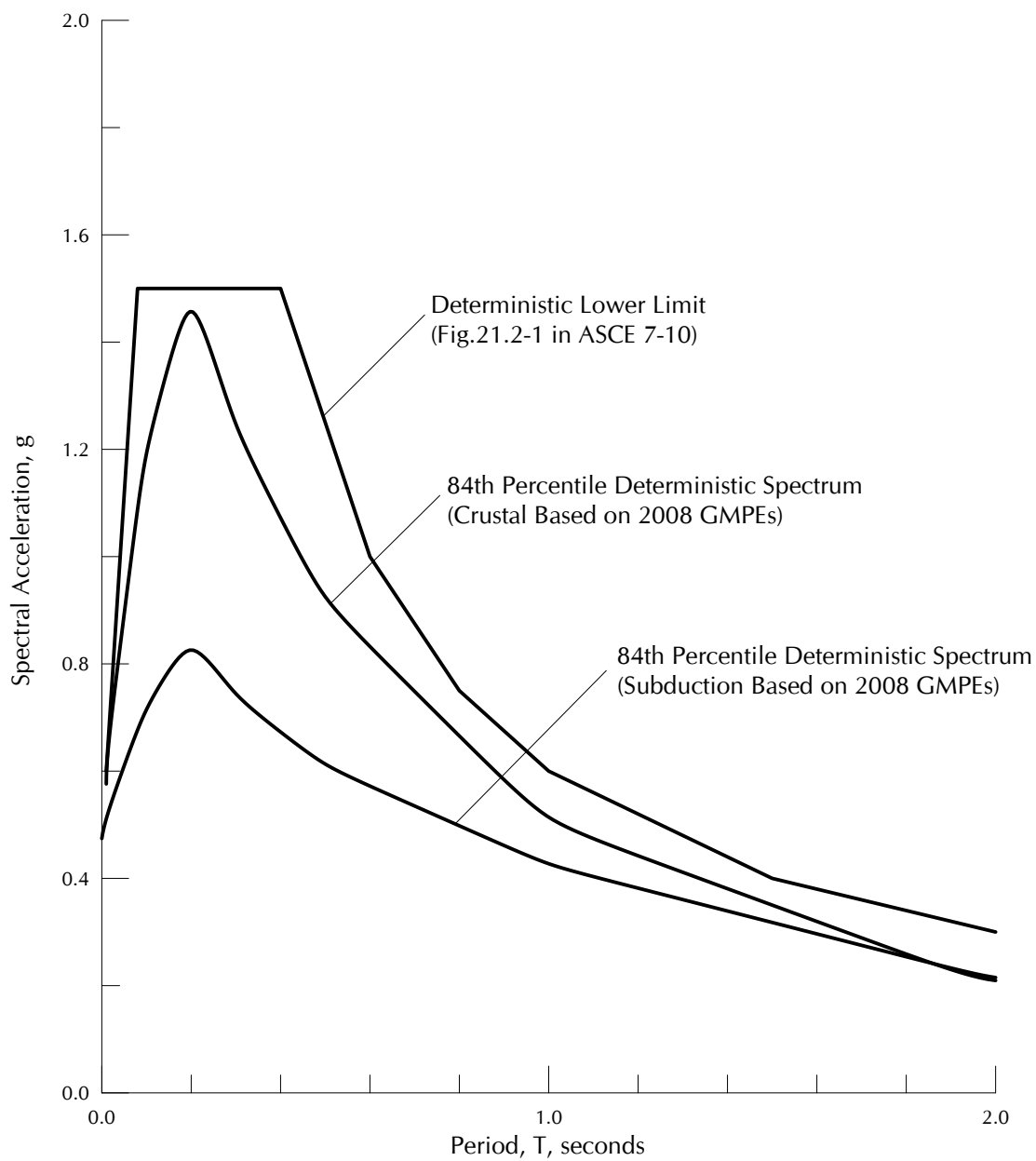


Figure 22. Magnitude-frequency distribution of the Cascadia subduction zone.

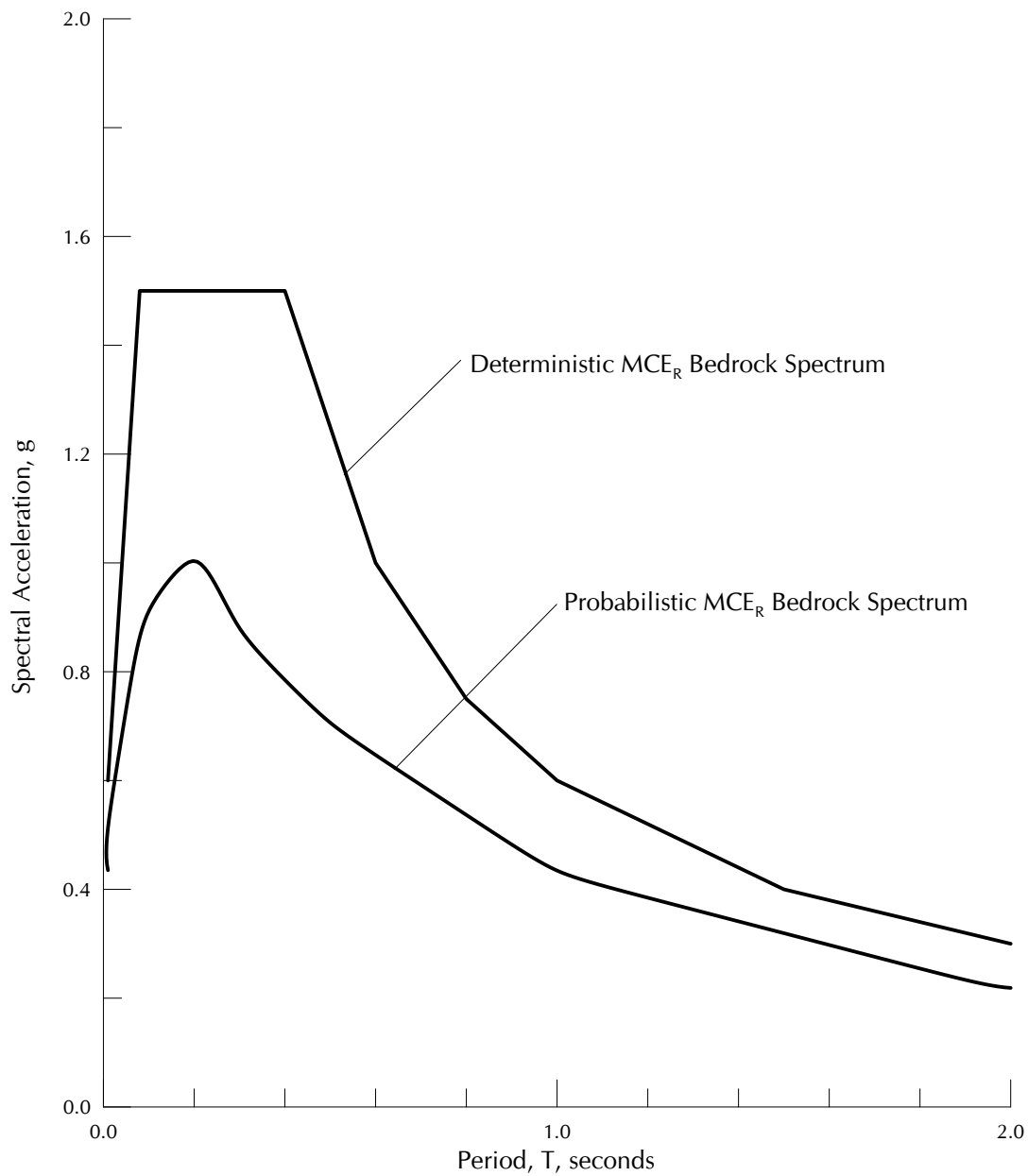
FROM: PETERSEN, M, FRANKEL, A, HARMSSEN, S, AND OTHERS, 2008, DOCUMENTATION FOR THE 2008 UPDATE OF THE UNITED STATES NATIONAL SEISMIC HAZARD MAPS: US GEOLOGICAL SURVEY, OPEN FILE REPORT 2008-1128



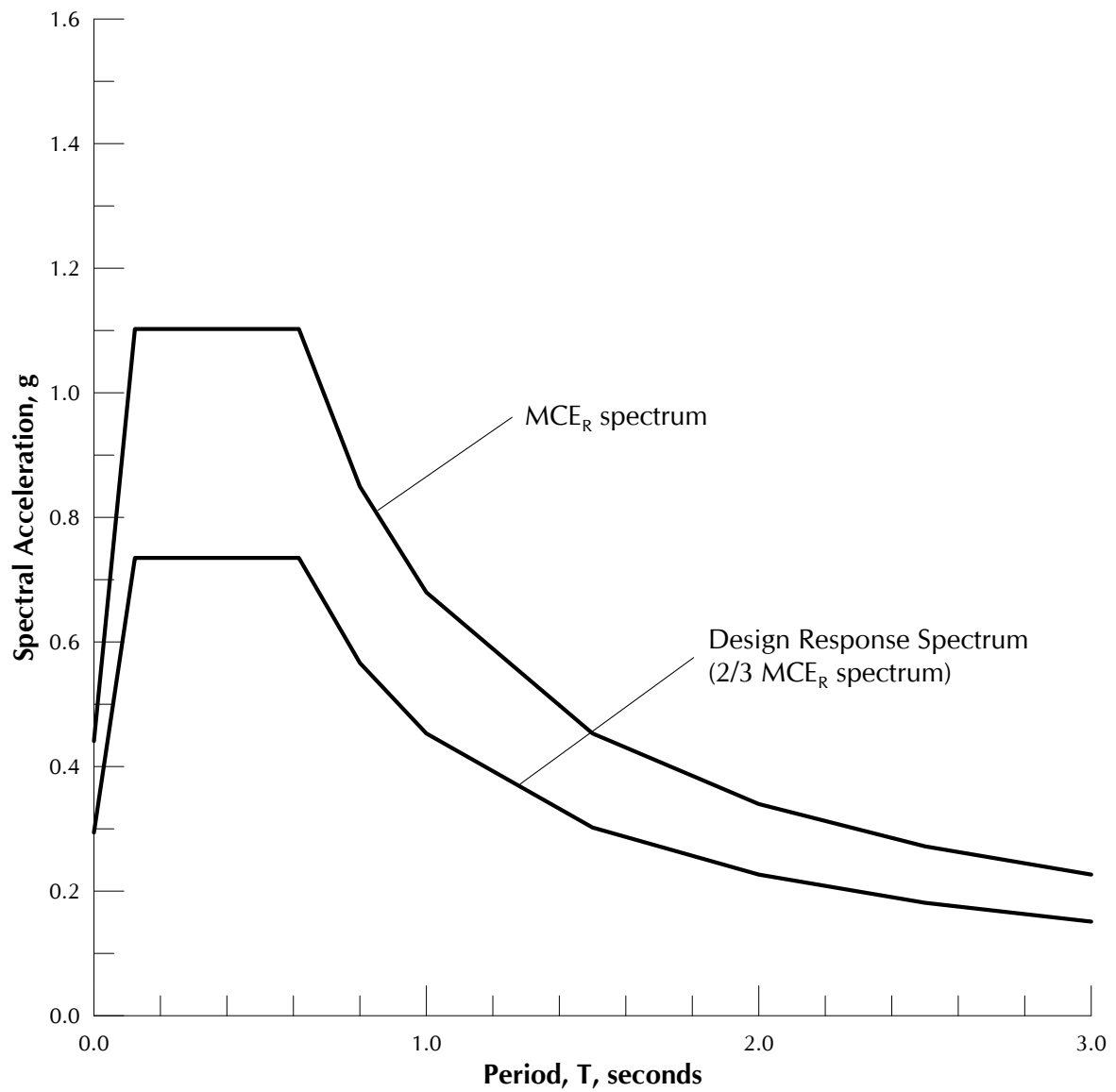
ASSUMED
MAGNITUDE-FREQUENCY DISTRIBUTION
(CASCADIA SUBDUCTION ZONE)



DETERMINISTIC MCE_R
BEDROCK SPECTRA COMPARISON
(5% DAMPING)



DETERMINISTIC & PROBABILISTIC MCE_R
BEDROCK SPECTRA COMPARISON
(5% DAMPING)



RECOMMENDED GROUND SURFACE
RESPONSE SPECTRA
(5% DAMPING)



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July 31, 2018

6111 ADDITIONAL GEOTECHNICAL CONSULTATION

Beaverton School District
16550 SW Merlo Road
Beaverton, OR 97003

Attention: Leslie Imes

**SUBJECT: Additional Geotechnical Consultation
Arts and Communications Magnet Academy
11375 SW Center Street
Beaverton, Oregon**

This letter provides additional geotechnical consultation performed for the Beaverton School District Arts and Communications Magnet Academy (ACMA) in Beaverton, Oregon. This letter presents the results of our review and evaluation of the north slope area at the subject site.

BACKGROUND INFORMATION

GRI completed a geotechnical investigation for the project and the results of our investigation were provided to Beaverton School District in our June 25, 2018, report titled, "Geotechnical Investigation and Site-Specific Seismic Hazard Study, Beaverton School District, Arts and Communications Magnet Academy, 11375 SW Center Street, Beaverton, Oregon". Additionally, GeoDesign, Inc. conducted a geotechnical investigation at the site in 2007, which is summarized in their August 15, 2007, report to the Beaverton School District titled, "Report of Geotechnical Engineering Services, Proposed Arts and Communication Magnet Academy Improvements, 11375 SW Center Street, Beaverton, Oregon."

CONSULTATION

Discussions with Beaverton School District personnel and Cameron McCarthy, project landscape architect, indicate Clean Water Services (CWS) requires an evaluation of the north slope to allow an adjustment of the standard CWS buffer of 35 ft to 15 ft. The existing slope has a height of about 30 to 35 ft and is generally inclined at about 25 to 28% or 4:1 (Horizontal:Vertical). A reconnaissance of the subject area indicates the slope is heavily vegetated.

A review of project plans shows the area adjacent to the slope will be re-seeded as lawn/native meadow. The lawn area will be an active use area for student physical recreation and may include a future playground.

Based on our geotechnical studies for the ACMA campus and review of the information provided, it is our opinion the implementation of a 15-ft-wide buffer will not materially affect the existing stability of the adjacent slope. This opinion is based on the subject area being used as a lawn area and playground.

This consultation letter is subject to the same limitations discussed in our June 25, 2018, geotechnical report.

Please contact the undersigned if you have any questions.

Submitted for GRI,



A. Wesley Spang, PhD, PE, GE
Principal