

PROJECT MANUAL / SPECIFICATIONS FOR
THE STREAM CENTER
SCHOOL OF THE HOLY CHILD

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VOLUME 2: SECTIONS 21000 - 30000

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THE UNDERSIGNED CERTIFIES THAT TO THE BEST OF HIS KNOWLEDGE, INFORMATION AND BELIEF, THE PLANS AND SPECIFICATIONS ARE IN ACCORDANCE WITH APPLICABLE REQUIREMENTS OF THE NEW YORK STATE UNIFORM FIRE PREVENTION AND BUILDING CODE, THE STATE ENERGY CONSERVATION CONSTRUCTION CODE, AND BUILDING STANDARDS OF THE EDUCATION DEPARTMENT, AND THAT THE PLANS AND SPECIFICATIONS REQUIRE THAT NO ASBESTOS CONTAINING MATERIAL SHALL BE USED.

Erik Kaeyer, AIA

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SLEEVES AND SLEEVE SEALS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

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. Jay R. Smith Mfg. Co.
 2. Zurn Industries, LLC.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

- A. Manufacturers: Subject to compliance with requirements, 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. Metraflex Company (The).
 3. Proco Products, Inc.
- B. Description: Modular sealing-element unit, designed for field assembly, for filling annular space between piping and sleeve.
1. Sealing Elements: EPDM-rubber or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 2. Pressure Plates: Stainless steel.
 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.

2.4 SLEEVE-SEAL 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. Metraflex Company (The).
 3. Proco Products, Inc.
- B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Install sleeves in seismic applications to provide adequate clearance according to NFPA 13 recommendations unless otherwise indicated.
 - 4. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

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. Install fittings in seismic applications to provide adequate clearance according to NFPA 13 recommendations unless otherwise indicated.
 - 3. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing.
 - 4. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 - 5. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 6. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

3.4 SLEEVE-SEAL-FITTING INSTALLATION

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

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:

- a. Piping Smaller Than NPS 6: Cast-iron wall sleeves or Galvanized-steel wall sleeves or Galvanized-steel-pipe sleeves or Sleeve-seal fittings.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves or Galvanized-steel wall sleeves or Galvanized-steel-pipe sleeves.
2. Exterior Concrete Walls below Grade:
- a. Piping [All Sizes]: Cast-iron wall sleeves with sleeve-seal system or Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
3. Concrete Slabs-on-Grade:
- a. Piping [All Sizes]: Cast-iron wall sleeves with sleeve-seal system or Galvanized-steel wall sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves with sleeve-seal system or Galvanized-steel-pipe sleeves.
 - 1) Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.
4. Concrete Slabs above Grade:
- a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves or Stack-sleeve fittings or Sleeve-seal fittings.
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves or Stack-sleeve fittings.
5. Interior Partitions:
- a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION

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ESCUTCHEONS FOR FIRE-SUPPRESSION PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

2.2 FLOOR PLATES

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

- B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - 2. Escutcheons for Existing Piping:
 - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.

- g. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
 - h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
 - i. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.
 - j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 21 05 23

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. Two-piece ball valves with indicators.
 - 2. Bronze butterfly valves with indicators.
 - 3. Iron butterfly valves with indicators.
 - 4. Check valves.
 - 5. Bronze OS&Y gate valves.
 - 6. Iron OS&Y gate valves.
 - 7. NRS gate valves.
 - 8. Trim and drain valves.

1.3 DEFINITIONS

- A. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.
- B. NRS: Non-rising 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Fivalco Inc.
2. Globe Fire Sprinkler Corporation.
3. Milwaukee Valve Company.

- B. Description:

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

2.4 IRON BUTTERFLY VALVES WITH INDICATORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Anvil International.
2. Globe Fire Sprinkler Corporation.
3. Kennedy Valve Company; a division of McWane, Inc.

- B. Description:

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

2.5 CHECK VALVES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. NIBCO INC.
2. Victaulic Company.

- B. Description:

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

2.6 BRONZE OS&Y GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. Milwaukee Valve Company.
2. NIBCO INC.
3. United Brass Works, Inc.

- B. Description:

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

2.7 IRON OS&Y GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. NIBCO INC.
2. Victaulic Company.
3. Watts; a Watts Water Technologies company.

- B. Description:

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

2.8 NRS GATE VALVES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. American Cast Iron Pipe Company.
2. NIBCO INC.
3. Victaulic Company.

- B. Description:

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

2.9 TRIM AND DRAIN VALVES

- A. Ball Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. NIBCO INC.
 - c. Potter Roemer LLC.
2. Description:
 - a. Pressure Rating: 175 psig or 300 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.

B. Angle 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. Fire Protection Products, Inc.
 - b. NIBCO INC.
 - c. United Brass Works, Inc.
2. Description:
 - a. Pressure Rating: 175 psig or 300 psig.
 - b. Body Material: Brass or bronze.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc: Bronze.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.

C. Globe Valves:

1. 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. NIBCO INC.
 - b. United Brass Works, Inc.
2. Description:

- a. Pressure Rating: 175 psig or 300 psig.
- b. Body Material: Bronze with integral seat and screw-in bonnet.
- c. Ends: Threaded.
- d. Stem: Bronze.
- e. Disc Holder and Nut: Bronze.
- f. Disc Seat: Nitrile.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.1 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 211200 "Fire-Suppression Standpipes" for application of valves in fire-suppression standpipes.
 - 2. Section 211313 "Wet-Pipe Sprinkler Systems" for application of valves in wet-pipe, fire-suppression sprinkler systems.
 - 3. Section 211316 "Dry-Pipe Sprinkler Systems" for application of valves in dry-pipe, fire-suppression sprinkler systems.
- 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 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.

- D. Install valves in horizontal piping with stem at or above the pipe center.
- E. Install valves in position to allow full stem movement.
- F. 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.
- G. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire-department connections.
- H. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

END OF SECTION

SECTION 21 05 29

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.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: 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.
- 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: Pre-galvanized or hot-dip galvanized.
 - 3. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Copper Pipe and Tube Hangers:
 - 1. Description: Copper-coated-steel, factory-fabricated components, NFPA approved, UL listed, or FM approved for fire-suppression piping support.

2. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Flex-Strut Inc.
 - 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 intumed 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.
8. Metallic Coating: one of the following Pre-galvanized G90, Electroplated zinc, Hot-dip galvanized.
9. Paint Coating: Green epoxy, acrylic, or urethane.

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. CADDY; a brand of nVent.
 - c. Carpenter & Paterson, Inc.
 - d. Empire Industries, Inc.
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: Select 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.
8. Metallic Coating: one of the following Pre-galvanized G90, Hot-dip galvanized.
9. Paint Coating: Green epoxy, acrylic, or urethane.

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. National Pipe Hanger Corporation.
 3. Pipe Shields Inc.
 4. Piping Technology & Products, Inc.
 5. Rilco Manufacturing Co., Inc.
- B. Insulation-Insert Material: one of the following Water-repellent-treated, ASTM C533, Type I calcium silicate with 100-psi, ASTM C552, Type II cellular glass with 100-psi or ASTM C591, Type VI, Grade 1 polyisocyanurate with 125-psi minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.
- F. Use thermal hanger shield for all insulated piping. This typically occurs where piping is heat traced.

2.6 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.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- a. Hilti, Inc.
 - b. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - c. MKT Fastening, LLC.
 - d. Simpson Strong-Tie Co., Inc.

- 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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. B-line, an Eaton business.
 - b. Hilti, Inc.
 - c. ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 2. Indoor Applications: Zinc-coated or Stainless steel.
 - 3. Outdoor Applications: Stainless steel.

2.7 EQUIPMENT SUPPORTS

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

2.8 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" 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. 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, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel or corrosion-resistant attachments for hostile environment applications. (this includes all outdoor and garage applications)
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use thermal hanger-shield inserts for insulated piping and tubing.
- I. 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. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8.
 - 4. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8.
 - 5. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3.
 - 6. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
 - 7. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 8. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
 - 9. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
- J. 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.
- K. Hanger-Rod Attachments: Comply with NFPA requirements.
- L. 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.
- M. 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.
- N. Comply with NFPA requirements for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- O. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- P. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION

SECTION 21 05 53

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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Brady Corporation.
 - b. Craftmark Pipe Markers.
 - c. Marking Services, Inc.
 - d. Seton Identification Products.
2. Material and Thickness: Brass, 0.032-inch or aluminum, 0.032-inch thick, with predrilled holes for attachment hardware.
 3. Letter Color: White.
 4. Background Color: Red.
 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Brady Corporation.
 - b. Craftmark Pipe Markers.
 - c. Marking Services, Inc.
 - d. Seton Identification Products.
 2. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch or 1/8-inch thick, with predrilled holes for attachment hardware.
 3. Letter Color: White.
 4. Background Color: Red.
 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. Brady Corporation.
 2. Craftmark Pipe Markers.
 3. Marking Seivics Inc.
 4. Seton Identification Products.
- B. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16-inch or 1/8-inch thick, with predrilled holes for attachment hardware.
- C. Letter Color: Yellow.
- D. Background Color: Black.
- 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 rivets or self-tapping screws.
- 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 PIPE LABELS

- 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. Brady Corporation.
 2. Craftmark Pipe Markers.

3. Marking Seivics Inc.
 4. Seton Identification Products.
- B. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service and showing flow direction according to ASME A13.1.
- C. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- D. Self-adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
- E. Pipe-Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with piping-system service lettering to accommodate both directions or as separate unit on each pipe label to indicate flow direction.
 2. Lettering Size: Size letters according to ASME A13.1 for piping with at least 1/2 inch for viewing distances up to 72 inches and proportionately larger lettering for greater viewing distances.
- F. Pipe-Label Colors:
1. Background Color: Safety Red.
 2. Letter Color: White.

2.4 STENCILS

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

2.5 VALVE TAGS

- 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. Brady Corporation.
 2. Craftmark Pipe Markers.
 3. Marking Seivics Inc.
 4. 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 or aluminum, 0.032-inch thick, with predrilled holes for attachment hardware.
 2. Fasteners: Brass wire-link chain, beaded chain or S-hook.
 3. Valve-Tag Color: Safety Red.
 4. Letter Color: White.
- 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.

2.6 WARNING TAGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Brady Corporation.
 2. Craftmark Pipe Markers.
 3. Marking Seivics Inc.
 4. Seton Identification Products.
- B. 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: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Color: Safety Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean piping and equipment surfaces of 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. 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.
- B. 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.
- C. Directional Flow Arrows: Arrows shall be used to indicate direction of flow in pipes including pipes where flow is allowed in both directions.

3.5 VALVE-TAG INSTALLATION

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

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 21 11 19

FIRE-DEPARTMENT CONNECTIONS

PART 1 - GENERAL

1.1 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. Exposed-type fire-department connections.
 - 2. Flush-type fire-department connections.
 - 3. Yard-type fire-department connections.

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 each fire-department connection.

PART 2 - PRODUCTS

2.1 EXPOSED-TYPE FIRE-DEPARTMENT CONNECTION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. American Fire Hose & Cabinet.
 - 2. Elkhart Brass Mfg. Co., Inc.
 - 3. Guardian Fire Equipment, Inc.
- B. Standard: UL 405.
- C. Type: Exposed, projecting, for wall mounting.
- D. Pressure Rating: 175 psig minimum.
- E. Body Material: Corrosion-resistant metal.

- F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Round, brass, wall type.
- I. Outlet: Back, with pipe threads.
- J. Number of Inlets: Minimum of Two. Contractor shall provide one inlet for each 250 GPM of system rated capacity.
- K. Escutcheon Plate Marking: Similar to "AUTO SPKR or AUTO SPKR & STANDPIPE or STANDPIPE."
- L. Finish: Polished chrome plated or Rough brass or bronze.
- M. Outlet Size: NPS 4 unless otherwise indicated.

2.2 FLUSH-TYPE FIRE-DEPARTMENT CONNECTION

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. American Fire Hose & Cabinet.
 - 2. Elkhart Brass Mfg. Co., Inc.
 - 3. Potter Roemer LLC.
- B. Standard: UL 405.
- C. Type: Flush, for wall mounting.
- D. Pressure Rating: 175 psig minimum.
- E. Body Material: Corrosion-resistant metal.
- F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Rectangular, brass, wall type.
- I. Outlet: With pipe threads.
- J. Body Style: Horizontal.

- K. Number of Inlets: Minimum of Two. Contractor shall provide one inlet for each 250 GPM of system rated capacity.
- L. Outlet Location: Back unless otherwise indicated
- M. Escutcheon Plate Marking: Similar to "AUTO SPKR OR AUTO SPKR & STANDPIPE OR STANDPIPE."
- N. Finish: Polished chrome plated or Rough brass or bronze.
- O. Outlet Size: NPS 4 unless otherwise indicated.

2.3 YARD-TYPE FIRE-DEPARTMENT CONNECTION

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Elkhart Brass Mfg. Co., Inc.
 - 2. Guardian Fire Equipment, Inc.
 - 3. Potter Roemer LLC.
- B. Standard: UL 405.
- C. Type: Exposed, freestanding.
- D. Pressure Rating: 175 psig minimum 300 psig.
- E. Body Material: Corrosion-resistant metal.
- F. Inlets: Brass with threads according to NFPA 1963 and matching local fire-department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
- G. Caps: Brass, lugged type, with gasket and chain.
- H. Escutcheon Plate: Round, brass, floor type.
- I. Outlet: Bottom, with pipe threads.
- J. Number of Inlets: Minimum of Two. Contractor shall provide one inlet for each 250 GPM of system rated capacity.
- K. Sleeve: Brass.
- L. Sleeve Height: 18 inches.
- M. Escutcheon Plate Marking: Similar to "AUTO SPKR or AUTO SPKR & STANDPIPE or STANDPIPE."
- N. Finish, Including Sleeve: Polished chrome plated or Rough brass or bronze.

- O. Outlet Size: NPS 4 unless otherwise indicated

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of fire-department connections.
- B. Examine roughing-in for fire-suppression standpipe system to verify actual locations of piping connections before fire-department connection installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install wall-type fire-department connections.
- B. Install yard-type fire-department connections in concrete slab support.
- C. Install two pipe bollards around each fire-department connection where subject to vehicular damage. Comply with requirements for bollards in Section 055000 "Metal Fabrications."
- D. Install automatic (ball-drip) drain valve at each check valve for fire-department connection.

END OF SECTION

SECTION 21 13 13
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. Specialty valves.
- 3. Sprinklers.
- 4. Alarm devices.
- 5. Pressure gages.

- B. Related Requirements:

- 1. Section 211119 "Fire Department Connections" for exposed-, flush-, and yard-type fire department connections.
- 2. Section 230523 "General-Duty Valves for Water-Based Fire-Suppression Piping" for ball, butterfly, check, gate, post-indicator, and trim and drain valves.

1.3 DEFINITIONS

- A. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175-psig maximum.
- B. High Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175-psig but not higher than of 300-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, sanitary and storm piping.
 2. Compressed air and medical gas piping.
 3. HVAC ductwork and piping.
 4. Items penetrating finished ceiling include the following:
 - a. Lighting fixtures and ceiling mounted controllers.
 - b. Air outlets and inlets.
 - c. Fire Alarm initiating and signaling devices.
- B. Qualification Data: For qualified Installer and professional engineer.
- C. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations and seismic calculations.
- D. Welding certificates.
- E. Fire-hydrant flow test report, recent within one (1) year.
- F. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and fire pump test reports.
- G. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

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

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Sprinkler Cabinets: Finished, wall-mounted, steel cabinet with hinged cover, and with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler used on Project.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

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

B. Welding Qualifications: Qualify procedures and operators according to 2010 ASME Boiler and Pressure Vessel Code.

1.9 FIELD CONDITIONS

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

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- #### A. Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
1. NFPA 13.
- #### B. Standard-Pressure Piping System Component: Listed for 175-psig minimum working pressure.
- #### C. High-Pressure Piping System Component: Listed for 300-psig working pressure.
- #### D. 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: Refer to Fire Protection contract drawings.
 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: According to NFPA 13 recommendations unless otherwise indicated.
 3. Minimum Density for Automatic-Sprinkler Piping Design: According to NFPA 13 recommendations unless otherwise indicated.
 4. Maximum Protection Area per Sprinkler: According to UL listing.
 5. Maximum Protection Area per Sprinkler: According to NFPA 13 recommendations unless otherwise noted.
- E. Total combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated.
- F. 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. Standard-Weight, Black-Steel Pipe: ASTM A 53/A 53M, Type E, Grade B. Pipe ends may be factory or field formed to match joining method.
- B. Schedule 10, Black-Steel Pipe: ASTM A 135/A 135M or ASTM A 795/A 795M, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10, plain end.
- C. Black-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, standard-weight, seamless steel pipe with threaded ends.
- D. Uncoated-Steel Couplings: ASTM A 865/A 865M, threaded.
- E. Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
- F. Malleable- or Ductile-Iron Unions: UL 860.
- G. Cast-Iron Flanges: ASME 16.1, Class 125.
- H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
 1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8-inch thick or ASME B16.21, nonmetallic and asbestos free or EPDM rubber gasket.
 - a. Class 125 and Class 250, Cast-Iron, Flat-Face Flanges: Full-face gaskets.

- b. Class 150 and Class 300, Ductile-Iron or -Steel, Raised-Face Flanges: Ring-type gaskets.
- 2. Metal, Pipe-Flange Bolts and Nuts: Carbon steel unless otherwise indicated.
- I. Steel Welding Fittings: ASTM A 234/A 234M and ASME B16.9.
 - 1. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- J. Grooved-Joint, Steel-Pipe Appurtenances:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Anvil International.
 - b. Tyco Fire Products LP.
 - c. Victaulic Company.
 - 2. Pressure Rating: 175-psig minimum or 300-psig where exposed to higher system pressures.
 - 3. Uncoated Grooved-End Fittings for Steel Piping: ASTM A 47/A 47M, malleable-iron casting or ASTM A 536, ductile-iron casting, with dimensions matching steel pipe.
 - 4. Grooved-End-Pipe Couplings for Steel Piping: AWWA C606 and UL 213 rigid pattern, unless otherwise indicated, for steel-pipe dimensions. Include ferrous housing sections, EPDM-rubber gasket, and bolts and nuts.

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.
 - 2. High-Pressure Piping Specialty Valves: 300-psig.
- C. Body Material: Cast or ductile iron.
- D. Size: Same as connected piping.
- E. End Connections: Flanged or grooved.
- F. Automatic (Ball Drip) Drain Valves:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

- a. 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International.
 - b. Tyco Fire Products LP.
 - c. Victaulic Company.
2. Standard: UL 213.
3. Pressure Rating: 175-psig minimum or 300 psig.
4. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
5. Type: Mechanical-tee and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire Products LP.
 - c. Victaulic Company.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum or 300 psig.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded or grooved.

C. Branch Line Testers:

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

D. Sprinkler Inspector's Test Fittings:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Tyco Fire Products LP.
 - b. Victaulic Company.
 - c. Viking Corporation.
2. Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
3. Pressure Rating: 175-psig minimum or 300 psig.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

E. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. CECA, LLC.
 - b. Corcoran Piping System Co.
 - c. Merit Manufacturing.
2. Standard: UL 1474.
3. Pressure Rating: 250-psig minimum or 300 psig.
4. Body Material: Steel pipe with EPDM-rubber O-ring seals.
5. Size: Same as connected piping.
6. Length: Adjustable.
7. Inlet and Outlet: Threaded.

F. Flexible Sprinkler Hose Fittings:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Victaulic Co.
 - b. Reliable Sprinkler
 - c. FlexHead Industries, Inc.
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 or 300 psig.
5. Size: Same as connected piping, for sprinkler.

2.5 SPRINKLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. Reliable Automatic Sprinkler Co., Inc. (The).
 2. Tyco Fire Products LP.
 3. Victaulic Company.
 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. Pressure Rating for High-Pressure Automatic Sprinklers: 300 psig.
- F. Automatic Sprinklers with Heat-Responsive Element:
 1. Early-Suppression, Fast-Response Applications: UL 1767.
 2. Nonresidential Applications: UL 199.
 3. Residential Applications: UL 1626.
 4. 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.
- 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 or Chrome-plated steel, two piece, with 1-inch vertical adjustment.
 2. Sidewall Mounting: Chrome-plated steel, one piece, flat.
- H. Sprinkler Guards:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Reliable Automatic Sprinkler Co., Inc. (The).
 - b. Tyco Fire Products LP.
 - c. Victaulic Company.
 - d. 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. Electrically Operated Alarm Bell:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - b. Notifier.
 - c. Potter Electric Signal Company, LLC.
2. Standard: UL 464.
3. Type: Vibrating, metal alarm bell.
4. Size: 8-inch minimum diameter.
5. Finish: Red-enamel factory finish, suitable for outdoor use.
6. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Water-Flow Indicators:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Potter Electric Signal Company, LLC.
 - b. System Sensor.
 - c. Viking Corporation.
 - d. Watts; a Watts Water Technologies company.
2. Standard: UL 346.
3. Water-Flow Detector: Electrically supervised.
4. Components: Two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-

set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.

5. Type: Paddle operated.
6. Pressure Rating: 250 psig.
7. Design Installation: Horizontal or vertical.

D. Pressure Switches:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Potter Electric Signal Company, LLC.
 - b. System Sensor.
 - c. Tyco Fire Products LP.
 - d. Viking Corporation.
2. Standard: UL 346.
3. Type: Electrically supervised water-flow switch with retard feature.
4. Components: Single-pole, double-throw switch with normally closed contacts.
5. Design Operation: Rising pressure signals water flow.

E. Valve Supervisory Switches:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fire-Lite Alarms, Inc.; a Honeywell International company.
 - 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, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. AGF Manufacturing Inc.
 2. AMETEK, Inc.
 3. Brecco Corporation.

- B. Standard: UL 393.
- C. Dial Size: 3-1/2- to 4-1/2-inch diameter.
- D. Pressure Gage Range: 0 to 300 psig.
- E. Label: Include "WATER" label on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in "Quality Assurance" Article. Flow test utilized for calculations shall be recent within one (1) year.
- B. Report test results promptly and in writing.

3.2 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 Engineer before deviating from approved working plans.
 - 2. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Piping Standard: Comply with NFPA 13 requirements for installation of sprinkler piping.
- C. Install seismic restraints on piping. Comply with NFPA 13 requirements for seismic-restraint device materials and installation.
- D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- E. Install unions adjacent to each valve in pipes NPS 2 and smaller.
- F. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 and larger end connections.
- G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, and sized and located according to NFPA 13.
- H. Install sprinkler piping with drains for complete system drainage.
- I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

- J. Install automatic (ball drip) drain valve at each check valve for fire-department connection, to drain piping between fire-department connection and check valve. Install drain piping to and spill over floor drain or to outside building.
- K. Install alarm devices in piping systems.
- L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13. In seismic-rated areas, refer to Section 210548 "Vibration and Seismic Controls for Fire-Suppression Piping and Equipment."
- M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft-metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they are not subject to freezing.
- N. Fill sprinkler system piping with water.
- O. Install electric heating cables and pipe insulation on sprinkler piping in areas subject to freezing. Comply with requirements for heating cables in Section 210533 "Heat Tracing for Fire-Suppression Piping" and for piping insulation in Section 210700 "Fire-Suppression Systems Insulation."
- P. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- Q. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 210517 "Sleeves and Sleeve Seals for Fire-Suppression Piping."
- R. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 210518 "Escutcheons for Fire-Suppression Piping."

3.3 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. 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.
- I. 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.
- J. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.
- K. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 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.

3.5 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center 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.

3.6 IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13. Comply with requirements for identification specified in Section 210553 "Identification for Fire-Suppression Piping and Equipment".
- B. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. 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. Coordinate with fire-pump tests. Operate as required.
 7. Verify that equipment hose threads are same as local fire department equipment.
- B. Sprinkler piping system will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 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.

3.9 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain sprinkler system and components.

3.10 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 or grooved ends, grooved-end fittings, grooved-end-pipe couplings, and grooved joints. Where piping between fire department connection and check valve is routed below grade, piping and fittings shall also be externally coated and wrapped per AWWA C203 or C105.
- B. Sprinkler specialty fittings may be used, downstream of control valves, instead of specified fittings.
- C. Standard-pressure, wet-pipe sprinkler system, NPS 1-1/2 and smaller, 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, black-steel pipe with plain ends; steel welding fittings; and welded joints.
- D. Standard-pressure, wet-pipe sprinkler system, NPS 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, black-steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 3. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.
 - 4. Schedule 10 black-steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.
 - 5. Schedule 10 black-steel pipe with plain ends; welding fittings; and welded joints.
- E. High-pressure, wet-pipe sprinkler system, [All Sizes], shall be one of the following:
 - 1. Standard-weight, black-steel pipe with plain ends; steel welding fittings; and welded joints.

3.11 SPRINKLER SCHEDULE

- A. Use sprinkler types as indicated on Fire Protection contract drawings.

END OF SECTION

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. These basic requirements apply to all Division 22000 Sections.
- B. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all Plumbing and related work for this project, as required by the contract documents.

1.2 RELATED SECTIONS

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

1.3 REFERENCES

- A. ASHRAE – American Society of Heating, Refrigerating and Air Conditioning Engineers Guides and Standards, latest editions.
- B. ASPE -- American Society of Plumbing Engineers.
- C. UL -- Underwriters Laboratory.
- D. NFPA -- National Fire Protection Association.

1.4 REGULATORY REQUIREMENTS

- A. IECC 2015
- B. IPC 2015
- C. IFGC 2015
- D. NY State SED Manual of Planning Standards – Current Addition

1.5 QUALITY ASSURANCE

- A. The Contractor shall have the work indicated on the drawings and/or specified in each section performed by vendors or mechanics experienced and skilled in its implantation or by a “Specialist”, “Specialty Contractor” or “Specialty Subcontractor” under contractual agreement with the Contractor.

These terms mean an individual or firm of established reputation, or, if newly organized, whose personnel have previously established a reputation in the same field, which is regularly engaged in, and which maintains a regular force of workmen skilled in either manufacturing or fabricating items required by the Contract, installing items required by the Contract, or otherwise performing work required by the Contract.

- B. Where the Contract Specifications require installation by a "Specialist," that term shall also be deemed to mean either the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform such work under the manufacturer's direct supervision.

1.6 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed arrangement of Work to meet Project conditions, including changes to Work specified in other Sections.

1.7 SCOPE OF WORK

- A. This Contractor shall be responsible for coordinating his work with all other trades.
- B. The Contractor shall provide all materials, labor, equipment, tools, appliances, services, hoisting, scaffolding, supervision and overhead for the furnishing and installing of all Plumbing work indicated on plan and in the specifications and related work including but not limited to the following:
- Sump Pumps
 - Domestic Water Recirculation Pumps
 - Domestic Hot Water Heaters and Expansion tanks
 - Plumbing Fixtures
 - Piping, Valves and fittings and specialties
 - Domestic systems
 - Drain, Waste, and Vent
 - Gas
 - Storm
 - Hangers and Supports
 - Backflow Preventers
 - Equipment Insulation
 - Pipe Insulation
 - Identification
 - Coordination
 - Phasing
 - Shop Drawings

- As-Built Drawings and Maintenance Manuals
- Warrantees

PART 2 PRODUCTS NOT USED

PART 3 EXECUTION

3.1 GENERAL

- A. Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.
- B. Where corrosion can occur, appropriate corrosion resistant materials and assembly methods must be used including isolation of dissimilar metals against galvanic interaction. Resistance to corrosion must be achieved by the use of the appropriate base materials. Coatings shall be restored to only when specifically permitted by the Specification.
- C. Construct all equipment in accordance with requirements of all applicable codes. All pressure vessels and safety devices that fall within the scope of the ASME Code shall conform to the Code and bear the ASME label or stamp.
- E. Match and balance all system components to achieve compatibility of equipment or satisfactory operation and performance throughout the entire operating temperature and control ranges. All installations shall be in accordance with manufacturer's recommendations.
- F. Provide all controls, wiring, piping, valves, accessories and other components necessary to make all systems complete and operable.
- G. The contractor shall warranty all work, including labor and materials, and equipment furnished and installed as part of this contract for a minimum period of year from the date of acceptance by the owner, in writing. Certain equipment, such as underground fuel tanks, may have longer warranties as indicated in the specifications. In such cases the longer of the two warranties shall prevail.

3.2 SHOP DRAWINGS AND SUBMITTALS (COORDINATE WITH DIVISION 1)

- A. Shop drawings and samples shall be prepared and submitted in accordance with the requirements established in the contract and shall consist of the all items listed in the following paragraph.
- B. Manufacturer's data or shop drawings giving full information as to dimensions, materials, and all information pertinent to the adequacy of the submitted equipment shall be submitted for review. Shop drawings shall include, but not be limited to the following:

- C. Submit all equipment noted and scheduled on plans including but not limited to the following:
- Ejector and sump pumps
 - Domestic Water Recirculation Pumps
 - Domestic Hot Water Heaters and Expansion tanks
 - Hot water heater
 - Gas booster
 - Plumbing Fixtures
 - Piping, Valves and fittings and specialties
 - Domestic systems
 - Drain, Waste, and Vent
 - Gas
 - Storm
 - Hangers and Supports
 - Backflow Preventers
 - Equipment Insulation
 - Pipe Insulation
 - Hangers and Inserts
 - Roof Drains
 - Floor Drains
 - Insulation
 - Piping Layout (3/8 scale)
 - Controls
- D. The contractor shall, upon award, submit a schedule for the engineer's review indicating when each of the above shop drawings shall be submitted. Submittals shall be made in a timely manner as the project progresses in accordance with the Construction manager or General contractor's work schedules. The contractor shall allow sufficient time for the engineers to perform his review. A minimum of 10 business days shall be required. Untimely submittals shall be cause for the owner to make a delay against the contractor.
- E. Demolition, purchase and or installation shall not begin until shop drawings pertaining to the equipment associated with any related portion of the work have been submitted.
- F. Coordination shop drawings shall indicate all new lights, walls, piping, ductwork, structural elements, existing work, etc. and dimension locations of plumbing piping including elevations in relation to these items.
- G. Where shop drawings have been reviewed by the Engineer, such review shall not be considered as a guarantee of measurements or building conditions. Where drawings have been reviewed, said review does not mean that drawings have been checked in detail; said review does not substantiate any quantities and in any way relieve the Contractor from his responsibility nor the necessity of furnishing materials or performing work required by the Contract Drawings and Specifications.

- H. Where substitutions are submitted for approval, the review shall be for general performance comparison to the specified product. Products shall not be reviewed for size, clearance, or coordination with other trades. Coordination with other trades shall be the responsibility of the contractor. And changes to existing conditions or changes required to the work of other trades such as a result of substituted material or equipment approved or not shall be the responsibility of this contractor.
- I. Approval of shop drawings
 - 1. The Contractor shall be specifically responsible for checking equipment dimensions and clearances and confirming that equipment will fit into the designated space and connect properly to adjoining equipment and/or materials.
 - 2. Submittals marked "Make Corrections Noted" give authority to proceed in accordance with the notes. However, if drawings are also marked "Amend and Resubmit", corrected drawings must be resubmitted for final review.
 - 3. Submittals marked "Rejected" do not give authority to proceed with any portion of the work shown there-on. Drawings must be resubmitted.
 - 4. Submittals marked "Rejected" or "Amend and Resubmit" shall include a specific written response to the engineer's comments. Resubmission of a submittal without a written response to the engineer's comments will be considered incomplete and shall be returned un-reviewed.

3.3 CHARTS AND TAGS

- A. The Contractor shall provide three sets of charts and diagrams of all piping systems indicating the number and location of valves, etc.
- B. All valves, and controls shall be designated with brass tags. Refer to section 22 05 23 Identification for HVAC Piping and equipment
- C. General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section

3.4 CODES AND STANDARDS

- A. All equipment and installation methods shall conform to the applicable standards and/or recommendations set forth in but not limited to the following;
 - IECC 2015
 - IPC 2015
 - IFGC 2015
 - NY State SED Manual of Planning Standards – Current Addition
- B. As well as all applicable referenced standards.

3.5 FEES & PERMITS

- A. The Contractor shall obtain all permits and pay all fees required for his work.

3.6 PAINTING

- A. All piping shall be painted in colors conforming with OSHA Standards.
- B. All hangers, nuts bolts and fasteners shall be galvanized steel or nickel plated supports shall be painted

3.7 RIGGING

- A. Furnish all labor, materials and equipment required to rig equipment and materials.
- D. The rigger shall secure any necessary permits and comply with all applicable Federal, State and local safety regulations. A copy of permits to be kept at both the project site and Engineer's Office.
- E. The rigger shall have a minimum of five (5) years of practical experience and hold a master riggers license if required.
- F. The procedure for rigging shall be submitted to the Engineer for review. All possible precautions should be taken to prevent damage to the structure, streets, sidewalks, curbs, lawns, etc.

3.8 CUTTING AND PATCHING

- A. All cutting and patching required for piping, etc., passing through walls, floors, and roof shall be provided by the General Contractor under this contract unless otherwise noted. This Contractor shall be responsible for any damage done to the structure due to his negligence.
- B. Patching materials and application shall match existing construction.
- C. Where applicable, new holes for piping installation shall be core drilled.
- D. Pipe Sleeves & Fire-stopping
 - 1. Provide for all pipes and other elements passing through floors, walls, partitions and structural elements, sleeves as specified. Sleeves shall be of adequate diameter to allow for a minimum of 3/4 inches clear all around sleeve and pipe.
 - 2. Where pipes penetrate fire rated assemblies, or where holes or voids are created to extend systems through fire rated assemblies (walls, floors, ceilings, structure, etc.); sleeves and fire-stopping systems shall be installed.

- G. Furnish access doors, to the General Contractor for installation where required in finished walls, partitions and the like for access to junction boxes, controls, valves, etc, concealed behind finished construction.

3.9 PROTECTION-COORDINATE WITH DIVISION 1

- A. Recommendations and Provisions of ANSI Bulletin A10.2 and OSHA shall be complied with in-so-far as applicable to the work.
- C. The Contractor shall provide temporary partitions or tarpaulins to protect adjacent spaces and/or equipment. He shall be responsible for any damage or injury to person or property of any character resulting from any act, omission, neglect or misconduct in his manner or method of executing his work.
- D. The Contractor shall restore at his own expense such property to a condition similar or equal to that existing before such damage or injury in an acceptable manner.
- E. The Contractor, furthermore, shall conduct his operations in such a manner as to prevent dust and debris from transferring on to adjoining property or into existing spaces.
- F. All openings cut in walls, floors, roof or ceilings of the building, for pipe, etc., shall be closed off with box-type temporary protective enclosures of ¼" tempered hardboard, except when mechanics are actually working at the particular opening. Enclosures shall be constructed of fireproof 2x4 frame, four (4) sides covered and made completely dust and watertight.
- G. All finished floor areas through which the contractor must pass with materials or equipment shall be protected with a layer of ¼" hardboard, "Masonite", laid with joints taped together.

3.10 EQUIPMENT SUPPORTS

- A. Provide supplementary steel dunnage, curbs, angle iron stands, etc., to properly set and install all equipment, including supports necessary to properly pitch piping.

3.11 WELDING SOLDERING BRAZING

- A. All equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.
- B. The handling and storage of all welding materials, acetylene and oxygen tanks, burners, and other equipment required for the execution of welding and cutting work shall be subject at all times to the approval of the Owner and/or Architect. All welding materials and gas tanks shall be promptly removed from the premises upon completion of each day's work or stored in a manner satisfactory to the owner. Welding and

equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.

- C. Provide all temporary exhaust, and ventilation air systems required during welding operations as required by OSHA. At no time shall the owner's new or existing HVAC equipment be used for ventilation during construction.

3.12 AS-BUILT DRAWINGS

- A. The Contractor shall provide a complete set of As-Built drawings showing actual installation and locations of all piping and roof drains.
- B. As-Built drawings shall be submitted as per contract requirements in accordance with Division 1.

3.13 CONDITIONS

- A. Inspection: Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence. Verify that the work of this Section may be completed in strict accordance with all pertinent codes and regulations, the approved Shop Drawings, and the Manufacturers' recommendations.
- B. Discrepancies: In the event of discrepancy, immediately notify the Engineer. Do not proceed in areas of discrepancy until all such discrepancies have been fully resolved.

3.14 INSTALLATION OF EQUIPMENT

- A. Locations: Install all equipment in the locations shown on the approved Shop Drawings except where specifically otherwise approved on the job by the Owner and/or Engineer.
- B. Interferences: Avoid interference with structure, and with work of other trades, preserving adequate headroom and clearing all doors and passageways to the approval of the Engineer.
- C. Inspection: Check each piece of equipment in the system for defects, verifying that all parts are properly furnished and installed, and that all items function properly, and that all adjustments have been made.

3.15 CLOSING-IN OF UNINSPECTED WORK

- A. General: Do not allow or cause any of the work to be covered up or enclosed until it has been inspected, tested, and accepted by the Engineer and by all other authorities having jurisdiction.

- B. Uncovering: Should any of the work of this Section be covered up or enclosed before it has been completely inspected, tested, and approved, do all things necessary to uncover all such work. After the work has been completely inspected, tested, and approved, provide all materials and labor necessary and make all repairs necessary to restore the work to its original and proper condition at no additional cost to the owner.

3.16 BUILDING ACCESS

- A. The Contractor shall inform himself fully regarding peculiarities and limitations of space available for the passage and installation of all equipment and materials under the Contract.
- B. Verify and coordinate removal of existing construction to suit conditions. Provide all labor and material to facilitate installation.

3.17 COOPERATION WITH OTHER TRADES / PHASING

- A. Cooperate with other trades in order that all systems in the work may be installed in the best arrangements.
- D. Coordinate as required with all other trades to share space in common areas and to provide the maximum of access to each system.
- E. This Contractor shall submit fully coordinated shop drawings showing all piping, ductwork and equipment's, as well as relevant work of all other trades such as light, conduits, structural and steel, which may impact the final size or placement of piping, roof drains, etc.
- F. The work shall be scheduled and phased in accordance with the requirements of the contract and the client. Prior to the commencement of work the PLUMBING contractor shall submit a schedule in writing to the Architect and owner for approval. There shall be no shutdowns of any systems without prior written approval from the owner. The contractor shall include in his bid all costs associated with providing temporarily piping, pumps, hot water heaters, to maintain operations outside the area of work while work is being performed. It shall also be noted that piping will have to be extended through the other areas in order to reach the area(s) under construction as part of this work. The contractor shall include in his bid all provisions to perform such phasing work. This note is typical for phases.

3.18 CLEANING

- A. It is the intent of the contract documents that all work, including the inside of equipment be left in a clean condition. All construction dirt shall be removed from material and equipment.

- B. All removed items shall be taken off the premises and discarded in a manner satisfactory to the Owner.

3.19 COMPLETENESS

- A. It is the intent of the contract documents to provide complete systems. Completeness shall mean not only that all material and equipment has been installed properly, but that all material and equipment is installed, adjusted, and operating as per the design intent in the opinion of the Engineer.

3.20 FIRE PREVENTION DURING HOT WORK

- A. Before starting operations, the Contractor shall furnish trained personnel to provide fire watches for locations where hot work is to be performed. One fire watcher may observe several locations in a relatively small contiguous area. Contractor shall furnish suitable type, fully charged, operable portable fire extinguisher to each fire watcher.
- B. The Contractor shall provide fire watchers who know how to operate the fire extinguisher, how to turn on a fire alarm and how to summon the fire department.
- C. Before starting operations, take suitable precautions to minimize the hazard of a fire communicating to the opposite side of walls, floors, ceilings and roofs from the operations.

3.21 SAFETY MEASURES

- A. Hot work shall not be done in or near rooms or areas where flammable liquids or explosive vapors are present or thought to be present. A combustible gas indicator (explosimeter) test shall be conducted to assure that each area is safe. The Contractor is responsible for arranging and paying for each test.
- B. Insofar as possible, the Contractor shall remove and keep the area free from all combustibles, including rubbish, paper and waste within a radius of 25 feet from hot operations.
- C. If combustible material cannot be removed, the Contractor shall furnish fireproof blankets to cover such materials. At the direction of the owner floors, walls, and ceilings of combustible material shall be wetted thoroughly with water before, during, and after operations sufficiently to afford adequate protection.
- D. Where possible, the Contractor shall furnish and use baffles of metal or gypsum board to prevent the spraying of sparks, hot slag and other hot particles into surrounding combustible material.
- E. The Contractor shall prevent the spread of sparks and particles of hot metal through open windows, doors, and holes and cracks in floors, walls, ceilings, and roofs.

- F. Cylinders of gas used in hot work shall be placed a safe distance from the work. The Contractor shall provide hoses and equipment free of deterioration, malfunction and leaks. Suitable supports shall be provided to prevent accidental overturning of cylinders. All cylinder control valves shall be shut off while in use with the gas pressure regulator set at 15 psi or less.
- G. When hot work operations are completed or ended for the day, each location of the day's work shall be inspected by the Contractor 30 to 60 minutes after completion of operations to detect for hidden or smoldering fires and to ensure that proper housekeeping is maintained. Contractor shall cleanup the area of work at the end of each shift or workday.
- H. Where sprinkler protection exists, the sprinkler system shall be maintained without interruption while operations are being performed. If operations are performed close to automatic sprinkler heads, gypsum board sheets or damp cloth guards may be used to shield the individual heads temporarily. The heads shall be inspected by the Contractor immediately after hot work operations cease, to ensure all materials have been removed from the heads and that the heads have not been damaged.
- I. Suitable type, fully charged, operable portable fire extinguisher shall be available at all times during hot work operations.
- J. If any of the above safeguards are not employed, or are violated, the Contracting owners Representative may, by written notice, stop the work until compliance is obtained. Such stoppage shall not relieve the Contractor from performing his work within the Contract period for the Contract price.

3.22 USE OF OWNERS EQUIPMENT

- A. The contractor shall not use any the owner's HVAC system or equipment, new or existing, for any purpose. The contractor shall provide temporary HVAC equipment, ductwork, power, and controls for use during construction for the purpose of ventilation, or heating during the construction process. All such equipment, ductwork, power, and controls shall be removed and the completion of work.

END OF SECTION

SECTION 22 05 17

SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 GENERAL

1.3 RELATED DOCUMENTS

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

1.3 SUMMARY

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

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Sustainable Design Submittals:
 - 1. Product Data: For sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials

PART 2 PRODUCTS

2.3 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 80, with plain ends and welded steel collar; zinc coated.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 80, zinc coated, with plain ends.

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

3.3 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. Smith, Jay R. Mfg. Co.
 - 2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

3.4 SLEEVE-SEAL SYSTEMS

- A. 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 or Nitrile (Buna N) 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, Stainless steel, Stainless steel, Type 316.
 - 5. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, ASTM B 63,3 Stainless steel, Stainless steel, Type 316 of length required to secure pressure plates to sealing elements.

3.5 SLEEVE-SEAL FITTINGS

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

3.6 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.

3.7 GROUT

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

PART 3 EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls. Sleeves for building service piping shall be one nominal line size larger than the service pipe.
- 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, and concrete walls as new slabs and walls are constructed.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.
 - 2. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Division 07 Section "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply

with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.8 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 Division 07 Section "Sheet Metal Flashing and Trim."
 - 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 - 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 07 Section "Penetration Firestopping."

3.8 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.

3.9 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.

3.10 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.

3.11 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 Sleeve-seal fittings.
 - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves, or Steel pipe sleeves with Sleeve-seal fittings.
 2. Exterior Concrete Walls below Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch minimum annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system or Steel pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch minimum annular clear space between piping and sleeve for installing sleeve-seal system.
 3. Concrete Slabs-on-Grade:
 - a. Piping Smaller Than NPS 6: Steel pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch minim annular clear space between piping and sleeve for installing sleeve-seal system.
 - b. Piping NPS 6 and Larger: Cast-iron pipe sleeves with sleeve-seal system or Steel pipe sleeves with sleeve-seal system.
 - 1) Select sleeve size to allow for 1-inch minimum 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 or Stack-sleeve fittings.
 - b. Piping NPS 6 and Larger: Steel pipe sleeves or Stack-sleeve fittings.
 5. Interior Partitions:

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- a. Piping Smaller Than NPS 6: Steel pipe sleeves.
- b. Piping NPS 6 and Larger: Galvanized-steel sheet sleeves.

END OF SECTION

SECTION 22 05 18

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 SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

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

2.2 FLOOR PLATES

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of 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 type.
 - b. Chrome-Plated Piping: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass or split-casting brass type with polished, chrome-plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
 - g. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.
 - 2. Escutcheons for Existing Piping: (not used)
 - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - e. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
 - f. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 22 05 19

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. Bimetallic-actuated thermometers.
 - 2. Liquid-in-glass thermometers.
 - 3. Thermowells.
 - 4. Dial-type pressure gages.
 - 5. Gage attachments.
 - 6. Test plugs.
 - 7. Test-plug kits.
 - 8. Sight flow indicators.
- B. Related Requirements:
 - 1. Section 221119 "Domestic Water Piping Specialties" for water meters.

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 MANUFACTURES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Trerice, H. O. Co.
 2. WATTS.
 3. Weiss Instruments, Inc.
 4. Weksler Glass Thermometer Corp.

2.2 BIMETALLIC-ACTUATED THERMOMETERS

- A. Standard: ASME B40.200.
- B. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
- C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.
- D. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- E. Connector Size: 1/2 inch, with ASME B1.1 screw threads.
- F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
- G. Window: Plain glass.
- H. Ring: Stainless steel.
- I. Element: Bimetal coil.
- J. Pointer: Dark-colored metal.
- K. Accuracy: Plus or minus 1 percent of scale range.

2.3 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Standard: ASME B40.200.
 2. Case: Cast aluminum; 6-inch nominal size.
 3. Case Form: Back angle unless otherwise indicated.
 4. Tube: Glass with magnifying lens and blue or red organic liquid.

5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.

a. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch, with ASME B1.1 screw threads.
9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
3. Case Form: Adjustable angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass.
7. Stem: Aluminum and of length to suit installation.

a. Design for Thermowell Installation: Bare stem.

8. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.4 THERMOWELLS

A. Thermowells:

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

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

2.5 PRESSURE GAGES

- A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - 1. Standard: ASME B40.100.
 - 2. Case: Liquid-filled AND Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 6-inch nominal diameter.
 - 3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 - 7. Pointer: Dark-colored metal.
 - 8. Window: Glass.
 - 9. Ring: Brass OR Stainless steel.
 - 10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
- B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
 - 1. Standard: ASME B40.100.
 - 2. Case: Liquid-filled and Sealed type; cast aluminum or drawn steel; 4-1/2-inch OR 6-inch nominal diameter with back or front flange and holes for panel mounting.
 - 3. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - 4. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - 5. Movement: Mechanical, with link to pressure element and connection to pointer.
 - 6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi.
 - 7. Pointer: Dark-colored metal.
 - 8. Window: Glass.
 - 9. Ring: Stainless steel.
 - 10. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Valves: Brass ball Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

- A. Description: Test-station fitting made for insertion into piping tee fitting.
- B. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

- C. Thread Size: or NPS 1/2, ASME B1.20.1 pipe thread.
- D. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- E. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

- A. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- B. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.
- C. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.
- D. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.
- E. Carrying Case: Metal or plastic, with formed instrument padding.

2.9 SIGHT FLOW INDICATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ARCHON Industries, Inc.
 - 2. Dwyer Instruments, Inc.
 - 3. Ernst Flow Industries.
 - 4. John C. Ernst Co., Inc.
- B. Description: Piping inline-installation device for visual verification of flow.
- C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.
- D. Minimum Pressure Rating: 150 psig.
- E. Minimum Temperature Rating: 200 deg F.
- F. End Connections for NPS 2 and Smaller: Threaded.
- G. End Connections for NPS 2-1/2 and Larger: Flanged.

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.
- K. Install thermometers in the following locations:
 - 1. Inlet and outlet of each water heater.
 - 2. Inlets and outlets of each domestic water heat exchanger.
 - 3. Inlet and outlet of each domestic hot-water storage tank.
- 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.
 - 4. Downstream of back flow preventer.

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 PRESSURE GAGE AND THERMOMETER SCHEDULE

- A. Install large size thermometers wherever space is available. Where space is limited or use compact style.
- B. Install all pressure gages locally unless space does not permit or the location is not readily visible. Then use remote reading pressure gage and install in location accessible and readily visible, as close to the point of reading as possible.
 - 1. Test plug with EPDM self-sealing rubber inserts.
- C. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

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

3.6 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Water Service Piping: 0 to 200 psi.
- B. Scale Range for Domestic Water Piping: 0 to 160 psi.
- C. Scale Range for Domestic Water Piping: 0 to 300 psi.

END OF SECTION

SECTION 22 05 23

GENERAL-DUTY VALVES OR 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. Brass ball valves.
 - 2. Bronze lift check valves.
 - 3. Bronze swing check valves.
 - 4. Bronze gate valves.
 - 5. Iron gate valves.
 - 6. Bronze globe valves.
 - 7. Iron globe valves.
- B. Related Sections:
 - 1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
 - 2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
 - 3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.3 DEFINITIONS

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

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 2. ASME B31.1 for power piping valves.
 - 3. ASME B31.9 for building services piping valves.
- C. NSF Compliance: NSF 61 for valve materials for potable-water service.
- D. Every pipe, fixture, and fitting used to convey water for potable use shall contain less than 0.25% of lead by weight according to lead free law "reduction of lead in drinking water act", nsf/ansi standard 372.

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

PART 2 PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.

- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Handwheel: For valves other than quarter-turn types.
 - 2. Handlever: For quarter-turn valves NPS 6 and smaller.
- E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
 - 1. Gate Valves: With rising stem.
 - 2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 3. Butterfly Valves: With extended neck.
- F. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Grooved: With grooves according to AWWA C606.
 - 3. Solder Joint: With sockets according to ASME B16.18.
 - 4. Threaded: With threads according to ASME B1.20.1.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRASS BALL VALVES

- A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
 - 1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Seats: PTFE or TFE.
 - g. Stem: Brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Full.
- B. Two-Piece, Regular-Port, Brass Ball Valves with Brass Trim:
 - 1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Forged brass.
 - f. Seats: PTFE or TFE.
 - g. Stem: Brass.
 - h. Ball: Chrome-plated brass.
 - i. Port: Regular.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

- A. Iron, Single-Flange Butterfly Valves with EPDM or NBR Seat and Aluminum-Bronze Disc:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Jenkins Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. NIBCO INC.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 250 psig.
 - c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
 - d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
 - e. Seat: EPDM or NBR.
 - f. Stem: One- or two-piece stainless steel.
 - g. Disc: Aluminum bronze.

2.4 IRON, GROOVED-END BUTTERFLY VALVES

- A. Iron, Grooved-End Butterfly Valves:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Kennedy Valve; a division of McWane, Inc.
 - b. Shurjoint Piping Products.
 - c. Tyco Fire Products LP; Grinnell Mechanical Products.
 - d. Victaulic Company.
 - 2. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating, NPS 8 and Smaller: 300 psig.
 - c. CWP Rating, NPS 10 and Larger: 200 psig.
 - d. Body Material: Coated, ductile iron.
 - e. Stem: Two-piece stainless steel.
 - f. Disc: Coated, ductile iron.
 - g. Seal: EPDM.

2.5 BRONZE LIFT CHECK VALVES

- A. Class 125, Lift Check Valves with Bronze Disc:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.

2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Disc: Bronze.

2.6 BRONZE SWING CHECK VALVES

- A. Class 125, Bronze Swing Check Valves with Bronze Disc:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Disc: Bronze.

2.7 BRONZE GATE VALVES

- A. Class 125, NRS Bronze Gate Valves:
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded or solder joint.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

- B. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.
 - d. Hammond Valve.
 - e. Milwaukee Valve Company.
 - f. NIBCO INC.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded or solder joint
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

2.8 IRON GATE VALVES

A. Class 150, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

B. Class 250, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. CWP Rating: 500 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free.

2.9 BRONZE GLOBE VALVES

- A. Class 125, Bronze Globe Valves with Bronze Disc:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Stockham Division.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded or solder joint.
 - e. Stem: Bronze.
 - f. Disc: Bronze, PTFE, or TFE
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

2.10 IRON GLOBE VALVES

- A. Class 125, Iron Globe Valves:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.; Crane Valve Group; Crane Valves.
 - b. Crane Co.; Crane Valve Group; Jenkins Valves.
 - c. Crane Co.; Crane Valve Group; Stockham Division.
 - d. Milwaukee Valve Company.
 - e. NIBCO INC.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 2. Description:
 - a. Standard: MSS SP-85, Type I.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Packing and Gasket: Asbestos free.
 - g.

2.11 LUBRICATED PLUG VALVES

- A. Plug valves are specified in Specification section 221114 Natural gas piping

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.
 - 2. Lift Check Valves: With stem upright and plumb.
- F. All valves used in any system shall have a pressure class that exceeds the pressure of the system it is installed in.

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 on plan, use the following:
 - 1. Shutoff Service: Ball, butterfly, or gate valves.
 - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - 3. Throttling Service: Globe or ball valves.
 - 4. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
 - b. NPS 2-1/2 and Larger for Sanitary Waste and Storm Drainage: Iron swing check valves with lever and weight or spring.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP 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 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 Steel Piping, NPS 2 and Smaller: Threaded ends.
 - 4. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 - 5. For Grooved-End Copper Tubing and Steel Piping: Valve ends may be grooved.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
 - 1. Brass Valves: May be provided with lead free solder-joint ends instead of threaded ends.
 - 2. Ball Valves: Two-piece, full port, brass with brass trim. Class 150
 - 3. Bronze Swing Check Valves: Class 150, bronze disc.
 - 4. Bronze Gate Valves: Class 150.
- B. Pipe NPS 2-1/2 and Larger:
 - 1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 - 2. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM, NBR seat, aluminum-bronze disc.
 - 3. Iron, Grooved-End Butterfly Valves: 175 CWP.
 - 4. Iron Gate Valves: Class 150.

3.6 SANITARY WASTE AND STORM-DRAINAGE 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: Class 150, nonmetallic disc.
 - 3. Bronze Gate Valves: Class 150.

- B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Iron Gate Valves: Class 150.
 3. Iron Swing Check Valves: Class 150.
 4. Iron Globe Valves: Class 150.

END OF SECTION

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

- B. Related Sections:

- 1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 fire-suppression piping Sections for pipe hangers for fire-suppression piping.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

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

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Sustainable Design Submittals:
 - 1. Environmental Product Declaration: For each product.
 - 2. Health Product Declaration: For each product.
 - 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Fiberglass strut systems.
 - 4. Pipe stands.
- D. 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. Design Calculations: Calculate requirements for designing trapeze hangers.
- E. Welding certificates.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
- B. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-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 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 1. National Pipe Hanger Corporation.
 2. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
 3. Rilco Manufacturing Co., Inc.
 4. Other manufacturers offering equivalent products.
- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength and vapor barrier.
- C. Insulation-Insert Material for Hot Piping: ASTM C 552, Type II cellular glass with 100-psig or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig minimum compressive strength.
- 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.

2.4 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.

2.5 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Stainless steel.
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

2.6 PIPE POSITIONING SYSTEMS

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

2.7 MISCELLANEOUS MATERIALS

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

2.8 VIBRATION ISOLATION HANGERS

- A. Vibration isolation pipe hangers; pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

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. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- D. Fastener System Installation:
 - 1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches 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.
- E. Pipe Stand Installation:
 - 1. Pipe Stand: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
- F. Pipe Positioning-System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. See Division 22 plumbing fixture Sections for requirements for pipe positioning systems for plumbing fixtures.

- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- 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 same thickness as piping insulation.

3.2 METAL FABRICATIONS

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

3.3 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.

3.4 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 a minimum dry film thickness of 2.0 mils.
- B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 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 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 copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- G. Use padded hangers for piping that is subject to scratching.
- H. Use thermal-hanger shield inserts for insulated piping and tubing.
- I. 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 might occur.
 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 might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 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 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 if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- J. 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.
- K. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. 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.
- L. 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-joint 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.
- M. 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.
- N. 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.
 9. Install vibration isolation hangers on all piping connected to motor driven equipment for a distance of 20' or the first two hangers.
- 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 pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

END OF SECTION

SECTION 22 05 53

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. Stencils.
 - 5. Valve tags.
 - 6. Warning tags.

1.3 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.

1.4 COORDINATION

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass 0.032-inch, stainless steel 0.025-inch, aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Letter Color: Black, Blue, Red, White, Yellow. As per ANSI depending on service
3. Background Color: Black, Blue, Red, White, Yellow as per ANSI depending on service
4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances 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.
6. Fasteners: Stainless-steel rivets or self-tapping screws.
7. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

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

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

2.3 PIPE LABELS

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

2.4 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Paint: Exterior, gloss, black unless otherwise indicated. Paint may be in pressurized spray-can form.
2. Identification Paint: Exterior, enamel in colors according to ASME A13.1 unless otherwise indicated.

2.5 VALVE TAGS

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

2.6 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 1. Size: 3 by 5-1/4 inches minimum.
 2. Fasteners: Brass grommet and wire.
 3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 4. Color: 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 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "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 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. 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. Low-Pressure Compressed Air Piping:
 - a. Background: Safety blue.
 - b. Letter Colors: White.
 2. High-Pressure Compressed Air Piping:
 - a. Background: Safety blue.
 - b. Letter Colors: White.
 3. Domestic Water Piping
 - a. Background: Safety green.
 - b. Letter Colors: White.
 4. Sanitary Waste and Storm Drainage Piping:
 - a. Background Color: Safety black
 - b. Letter Color: White

3.3 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: 1-1/2 inches round.
 - b. Hot Water: 1-1/2 inches round.
 - c. Sanitary waste and storm drainage: 1-1/2 inches round.
 - 2. Valve-Tag Color:
 - a. Cold Water: Green.
 - b. Hot Water: Green.
 - c. Sanitary waste and storm drainage: Natural.
 - 3. Letter Color:
 - a. Cold Water: White.
 - b. Hot Water: White.
 - c. Sanitary waste and storm drainage: white.

3.4 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 22 07 19

PLUMBING PIPING INSULATION AND JACKETS

PART 1 - GENERAL

1.1 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. Sanitary waste piping exposed to freezing conditions.
 - 5. Storm-water piping exposed to freezing conditions.
 - 6. Roof drains and rainwater leaders.
 - 7. Supplies and drains for handicap-accessible lavatories and sinks.
- B. Related Sections:
 - 1. Section 221116 "Domestic Water Piping."

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).
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at pipe expansion joints for each type of insulation.
 - 3. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 4. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 5. Detail application of field-applied jackets.

- C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
 - 1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
 - 2. Jacket Materials for Pipe: 12 inches long by NPS 2.
 - 3. Sheet Jacket Materials: 12 inches square.
 - 4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.
- C. Field quality-control reports.

1.5 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.

1.6 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 220529 "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.

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 "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. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. 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, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pittsburgh Corning Corporation; Foamglass.
 - 2. Block Insulation: ASTM C 552, Type I.

3. Special-Shaped Insulation: ASTM C 552, Type III.
 4. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
 5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
- G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.
- H. 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, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Friendly Feel Duct Wrap.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; SOFTR All-Service Duct Wrap.
- I. Mineral-Fiber, Preformed Pipe Insulation:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000-Degree Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.
 - e. Owens Corning; Fiberglas Pipe Insulation.
 2. Type I, 850 Deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Super-Stik.
- B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Thermokote V.
- C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aero seal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 3. Adhesive shall comply with the testing and product requirements of the California Department of Public Health's "Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 4. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 5. Wet Flash Point: Below 0 deg F .
 6. Service Temperature Range: 40 to 200 deg F.
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 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. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-20.
 - d. Mon-Eco Industries, Inc.; 22-25.
 2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- F. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.

- b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.
2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass and Phenolic Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

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

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

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

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.

2.6 FIELD-APPLIED JACKETS

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

- a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

C. Metal Jacket:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
2. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.

Among the three moisture barriers in first subparagraph below, 1-mil (0.025-mm) barrier provides the least protection against galvanic corrosion, 3-mil (0.075-mm) barrier offers better protection, and polysurlyn barrier offers the best protection. For most indoor applications, 1-mil (0.025-mm) barrier is adequate. For outdoor applications, select either 3-mil (0.075-mm) or polysurlyn barrier.

- c. Moisture Barrier for Indoor Applications: 1-mil- thick, heat-bonded polyethylene and kraft paper.
- d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

D. Underground Direct-Buried Jacket: 125-mil- thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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. Pittsburgh Corning Corporation; Pittwrap.
 - b. Polyguard Products, Inc.; Insulrap No Torch 125.

2.7 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 2. Width: 3 inches.
 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. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 2. Width: 3 inches.
 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.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches.
 3. Thickness: 6 mils.
 4. Adhesion: 64 ounces force/inch in width.

5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 488 AWF.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - c. Compac Corporation; 120.
 - d. Venture Tape; 3520 CW.
2. Width: 2 inches.
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. Bands:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping and Seals.
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.

2.9 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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. Insul-Tect Products Co.; a subsidiary of MVG Molded Products.
 - b. McGuire Manufacturing.
 - c. Truebro; a brand of IPS Corporation.

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

PART 3 - EXECUTION

3.1 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 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.

3.3 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. 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.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

O. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Cleanouts.

3.4 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "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, 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.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of 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 services, secure laps with outward clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient services, 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 cut sections of cellular-glass block insulation of same thickness as pipe 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. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. 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.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- #### A.
1. 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.

3.8 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.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where 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.

C. 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.

- D. 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.

3.10 FINISHES

- A. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- B. Do not field paint aluminum or stainless-steel jackets.

3.11 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. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.12 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.

3.13 PIPING INSULATION SCHEDULE

- A. Domestic Cold Water:

1. Smaller than NPS 1 ½": Insulation shall be one of the following:
 - a. Cellular Glass: ½ inches thick.
 - b. Flexible Elastomeric: ½" inch thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 2. NPS 1 1/2 and Larger: Insulation shall be one of the following:
 - a. Cellular Glass: 1" inches thick.
 - b. Flexible Elastomeric: 1" inch thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1" inch thick.
- B. Domestic Hot and Recirculated Hot Water: (T < 140° F)
1. Smaller than NPS 1 ½": Insulation shall be one of the following:
 - a. Cellular Glass: 1 inch thick.
 - b. Flexible Elastomeric: 1 inch thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 2. NPS 1 ½" and Larger: Insulation shall be one of the following:
 - a. Cellular Glass: 1-1/2 inches thick.
 - b. Flexible Elastomeric: 1-1/2 inches thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.
- C. Domestic Hot and Recirculated Hot Water: (T 141°F to 200° F)
1. Smaller than NPS 1 ½": Insulation shall be one of the following:
 - a. Cellular Glass: 1 1/2" inch thick.
 - b. Flexible Elastomeric: 1 ½" inch thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 1/2" inch thick.
 2. NPS 1 ½" and Larger: Insulation shall be one of the following:
 - a. Cellular Glass: 2 inches thick.
 - b. Flexible Elastomeric: 2 inches thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches thick.
- D. Roof Drain; bodies, storm risers and horizontal offsets inside building:
1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Cellular Glass: 1 1/2 inches thick.
 - b. Flexible Elastomeric: 1 inch thick.
 - c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- E. All Sanitary waste, storm and domestic piping in garages or areas not heated:
1. All Pipe Sizes: Insulation shall be one of the following:

- a. Cellular Glass: 2" inches thick.
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inch thick.
- F. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures not concealed by millwork:
- 1. All Pipe Sizes: Insulation shall be one of the following:
 - a. Flexible Elastomeric: 1/2 inch thick cold water and drain, 1" hot water
 - b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick cold water and drain, 1" hot water
 - c. Jacket with protective shielding guards. Refer to section 2.9

3.14 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. ASJ
- D. Piping, Exposed:
 - 1. All exposed sanitary, waste, storm, hot water cold water, and vent piping and fittings which are exposed to view in public areas, particularly the Cafeteria, Stage, Gymnasium, Atrium, (as well as insulated piping in equipment rooms), shall be completely covered with white Zeston 2000 PVC insulated piping and fitting covers. Apply as per manufacturer with Perma Weld adhesive. All labels and flow arrows shall be applied over PVC jacket

END OF SECTION

SECTION 22 11 16
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. Ductile iron pipe and fittings
- 3. Pipe joining materials
- 4. Specialty valves
- 5. Transition fittings
- 6. Dielectric fittings.

- B. Related Section:

- 1. Division 22 Section "Facility Water Distribution Piping" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.

1.3 SUBMITTALS

- A. Product Data: For the following products:

- 1. Specialty valves.
- 2. Transition fittings.
- 3. Dielectric fittings.
- 4. Flexible connectors.

- B. Water Samples: Specified in "Cleaning" Article.

- C. Coordination Drawings: For piping in equipment rooms and other congested areas, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

- 1. Fire-suppression-water piping.
- 2. Domestic water piping, storm water piping and sanitary piping.

3. HVAC hydronic piping and Ductwork.
4. Electrical conduits.

D. Field quality-control reports.

E. 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.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61 for potable domestic water piping and components.

1.5 PROJECT CONDITIONS

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Comply with requirements in "Piping Schedule" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.
- 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 Standard 372 for low lead.

2.2 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
 1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.

2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

B. 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.

C. Copper-Tube, Extruded-Tee Connections:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Apollo Valves; Conbraco Industries, Inc.
 - b. Elkhart Products Corporation.
 - c. Mueller Industries, Inc.
 - d. NIBCO INC.
2. Description: Tee formed in copper tube according to ASTM F 2014.

2.3 DUCTILE-IRON SERVICE PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe:

1. AWWA C151/A21.51, with mechanical-joint bell and plain spigot end unless grooved or flanged ends are indicated.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Standard-Pattern, Mechanical-Joint Fittings:

1. AWWA C110/A21.10, ductile or gray iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

C. Compact-Pattern, Mechanical-Joint Fittings:

1. AWWA C153/A21.53, ductile iron.
2. Glands, Gaskets, and Bolts: AWWA C111/A21.11, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

D. Plain-End, Ductile-Iron Pipe: AWWA C151/A21.51.

2.4 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. 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 general-duty brazing unless otherwise indicated.

2.5 SPECIALTY VALVES

- A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.
- B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.6 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.

2.7 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- 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 Regulator Co.; a division of Watts Water Technologies, Inc.

- d. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

- a. Pressure Rating: 150 psig at 180 deg F.
- b. 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. EPCO Sales, Inc.
- d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

- a. Factory-fabricated, bolted, companion-flange assembly.
- b. Pressure Rating: 150 psig.
- c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

- 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. Central Plastics Company.
- d. Pipeline Seal and Insulator, Inc.

2. Description:

- a. Nonconducting materials for field assembly of companion flanges.
- b. Pressure Rating: 150 psig.
- c. Gasket: Neoprene or phenolic.
- d. Bolt Sleeves: Phenolic or polyethylene.
- e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

- a. Calpico, Inc.

- b. Lochinvar Corporation.
- 2. Description:
 - a. Galvanized-steel coupling.
 - b. Pressure Rating: 300 psig at 225 deg F.
 - c. End Connections: Female threaded.
 - d. Lining: Inert and noncorrosive, thermoplastic.
- F. Dielectric Nipples:
 - 1. Standard: IAPMO PS 66.
 - 2. Electroplated steel nipple complying with ASTM F1545.
 - 3. Pressure Rating and Temperature: 300 psig at 225 deg F.
 - 4. End Connections: Male threaded or grooved.
 - 5. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install 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 in Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
- E. Install shutoff valve immediately upstream of each dielectric fitting.
- F. Install domestic water piping level without pitch and plumb.
- G. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- H. 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.

- I. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- J. Install piping adjacent to equipment and specialties to allow service and maintenance.
- K. Install piping to permit valve servicing.
- L. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
- M. Install piping free of sags and bends.
- N. Install fittings for changes in direction and branch connections.
- O. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- P. 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."
- Q. Install thermostats in hot-water circulation piping. Comply with requirements for thermostats in Section 221123 "Domestic Water Pumps."
- R. 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."
- S. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- T. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- U. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons 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."

3.2 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: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.
- E. Soldered Joints: 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. Copper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints.
- G. Joint Construction for Grooved-End, Ductile-Iron Piping: Make joints according to AWWA C606. Cut round-bottom grooves in ends of pipe at gasket-seat dimension required for specified (flexible or rigid) joint. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections over gasket with keys seated in piping grooves. Install and tighten housing bolts
- H. 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.
- I. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.3 VALVE INSTALLATION

- A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.
- B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.
- C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
 - 1. Hose-End Drain Valves: At low points in water mains, risers, and branches.

2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.

3.4 DIELECTRIC FITTING INSTALLATION

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

3.5 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.
- B. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
 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.
- F. Install supports for vertical copper tubing every 10 feet
- G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

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

3.7 IDENTIFICATION

- A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.
- B. Label pressure piping with system operating pressure.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Piping Inspections:
 - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - 2. 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:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.

4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. 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.
3. 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.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
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 for corrective action required.

- D. Domestic water piping will be considered defective if it does not pass tests and inspections.

- E. Prepare test and inspection reports. Submit for engineers review and approval.

3.9 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. Remove plugs used during testing of piping and for temporary sealing of piping during installation.
5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
6. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
7. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 CLEANING

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

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.

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

3.11 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 one of the following:
 1. Soft copper tube, ASTM B 88, Type K, ASTM B 88 Type L; wrought-copper, solder-joint fittings; and brazed, copper pressure-seal fittings; and pressure-sealed joints.
- E. Under-building-slab, domestic water, building-service piping, NPS 4 to NPS 8 and larger, shall be one of the following:
 1. Soft copper tube, ASTM B 88, Type K, ASTM B 88, Type L; wrought-copper, solder-joint fittings; and brazed joints.
 2. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
- F. Under-building-slab, combined domestic water, building-service, and fire-service-main piping, NPS 6 to NPS 12, shall be the following:

1. Mechanical-joint, ductile-iron pipe; standard-pattern, mechanical-joint fittings; and mechanical joints.
- G. Under-building-slab, domestic water distribution piping, NPS 3 and smaller, shall be the following:
 1. Hard copper pipe type L, ASTM B42 or soft copper tube type L, ASTM B 88. wrought-copper, solder-joint fittings; and brazed joints.
- H. Aboveground domestic water distribution piping, NPS 2 and smaller, shall be one of the following:
 1. Hard copper tube, ASTM B 88, Type L; copper, solder-joint fittings; and joints.
- I. Aboveground domestic water piping, NPS 2-1/2 to NPS 4, shall be one of the following:
 1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and brazed soldered joints.
- J. Aboveground domestic water piping, NPS 5 to NPS 8, shall be one of the following:
 1. Hard copper tube, ASTM B 88, Type L; cast- or wrought-copper, solder-joint fittings; and brazed soldered joints.
 2. Hard copper tube, ASTM B 88, Type L or; grooved-joint, copper-tube appurtenances; and grooved joints.
- K. Aboveground, combined domestic water-service and fire-service-main piping, NPS 6 to NPS 12, shall be one of the following:
 1. Plain-end, ductile-iron pipe; grooved-joint, ductile-iron-pipe appurtenances; and grooved joints.

3.12 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 butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
 3. Hot-Water Circulation Piping, Balancing Duty: Memory-stop 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.
- C. Iron grooved-end valves may be used with grooved-end piping.

END OF SECTION

SECTION 22 11 19

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. This Section includes the following domestic water piping specialties:
 - 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. Drain valves.
 - 11. Water hammer arresters.
 - 12. Air vents.
 - 13. Trap-seal primer valves.
 - 14. Trap seal primer systems
 - 15. Flexible connections
- B. Related Sections include the following:
 - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
 - 2. Division 22 Section "Domestic Water Piping".

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR PIPING SPECIALTIES

- A. Potable-water piping and components shall comply with NSF 61 Annex G and NSF 14.

2.2 PERFORMANCE REQUIREMENTS

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

2.3 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 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. FEBCO
 - b. Zurn Industries, LLC
 - c. Watts
 - d. Ames Co.
 - 2. Standard: ASSE 1001.

3. Size: NPS 1/4 to NPS 3, as required to match connected piping.
4. Body: Bronze.
5. Inlet and Outlet Connections: Threaded.
6. Finish: Chrome plated.

B. Hose-Connection Vacuum Breakers:

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. FEBCO
 - b. Zurn Industries, LLC
 - c. Watts
 - d. Ames Co.
- 2.
3. Standard: ASSE 1011.
4. Body: Bronze, nonremovable, with manual drain.
5. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
6. Finish: Chrome or nickel plated.

C. Laboratory-Faucet Vacuum Breakers:

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. FEBCO
 - b. Zurn Industries, LLC
 - c. Watts
 - d. Ames Co.
- 2.
3. Standard: ASSE 1035.
4. Size: NPS 1/4 or NPS 3/8 matching faucet size.
5. Body: Bronze.
6. End Connections: Threaded.
7. Finish: Chrome plated.

2.4 BACKFLOW PREVENTERS

A. Double-Detector Check Backflow-Prevention Assemblies:

1. Ames Co. or a comparable product by one of the following as indicated on Drawings:
 - a. FEBCO; SPX Valves & Controls.
 - b. Zurn Plumbing Products Group; Wilkins Div.
 - c. Watts Industries
2. Standard: ASSE 1015.
3. Operation: Continuous-pressure applications, unless otherwise indicated.
4. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.

5. Size, Design Flow Rate: as indicated on drawings.
6. Body: stainless steel.
7. End Connections: Flanged.
8. Configuration: Designed for horizontal, straight through flow.
9. Accessories:
 - a. Valves: Outside screw and yoke gate-type with flanged ends on inlet and outlet.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Ames Co. model as indicated on Drawings, or a comparable product by one of the following as indicated on Drawings:
 - a. Watts Industries.
 - b. Conbraco Industries, Inc.
 - c. FEBCO; SPX Valves & Controls.
2. Standard: ASSE 1013.
3. Operation: Continuous-pressure applications.
4. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
5. Body: Bronze for NPS 2 and smaller.
6. End Connections: Threaded for NPS 2 and smaller.
7. Configuration: Designed for horizontal, straight through flow.
8. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Beverage-Dispensing-Equipment Backflow Preventers:

1. Ames Co. or a comparable product by one of the following as indicated on Drawings:
 - a. FEBCO; SPX Valves & Controls.
 - b. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1022.
3. Operation: Continuous-pressure applications.
4. Size: NPS 1/4 or NPS 3/8
5. Body: Stainless steel.
6. End Connections: Threaded.

D. Dual-Check-Valve Backflow Preventers:

1. Ames Co. or a comparable product by one of the following as indicated on Drawings:
 - a. FEBCO; SPX Valves & Controls.
 - b. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1024.

3. Operation: Continuous-pressure applications.
 4. Size: [NPS 1/2] [NPS 3/4] [NPS 1] [NPS 1-1/4].
 5. Body: Bronze with union inlet.
- E. Carbonated-Beverage-Dispenser, Dual-Check-Valve Backflow Preventers:
1. Ames Co. or a comparable product by one of the following as indicated on Drawings:
 - a. FEBCO; SPX Valves & Controls.
 - b. Zurn Plumbing Products Group; Wilkins Div.
 - 2.
 3. Standard: ASSE 1032.
 4. Operation: Continuous-pressure applications.
 5. Size: NPS 1/4 or NPS 3/8 (DN 8 or DN 10).
 6. Body: Stainless steel.
 7. End Connections: Threaded.
- F. Backflow-Preventer Test Kits:
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. FEBCO; SPX Valves & Controls.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
 2. Description: Factory calibrated, with gages, fittings, hoses, and carrying case with test-procedure instructions.

2.5 WATER PRESSURE-REDUCING VALVES

- A. Water Regulators:
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. Zurn
 - b. Watts
 - c. Josam.
 2. Standard: ASSE 1003.
 3. Pressure Rating: Initial working pressure of 150 psig.
 4. Body: Bronze with chrome-plated finish for NPS 2 and smaller; cast iron with interior lining that complies with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3.
 5. Valves for Booster Heater Water Supply: Include integral bypass.
 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.
- B. Water-Control Valves:

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. FEBCO
 - b. Zurn Industries, LLC
 - c. Watts
 - d. Ames Co.
2. Description: Pilot-operated, diaphragm-type, single-seated, main water-control valve.
3. Pressure Rating: Initial working pressure of 150 psig minimum with AWWA C550 or FDA-approved, interior epoxy coating. Include small pilot-control valve, restrictor device, specialty fittings, and sensor piping.
4. Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
 - a. Pattern: Angle or Globe-valve design.
 - b. Trim: Stainless steel.
5. Design Flow: as per plan
6. Design Inlet Pressure: as per plan
7. Design Outlet Pressure Setting: as per plan
8. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.

2.6 BALANCING VALVES

A. Memory-Stop Balancing Valves:

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. Conbraco Industries, Inc.
 - b. Crane Co.; Crane Valve Group
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig minimum CWP.
4. Size: NPS 2 or smaller.
5. Body: Copper alloy.
6. Port: Standard or full port.
7. Ball: Chrome-plated brass.
8. Seats and Seals: Replaceable.
9. End Connections: Solder joint or threaded.
10. Handle: Vinyl-covered steel with memory-setting device.

2.7 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Individual-Fixture, Water Tempering Valves:

1. Lawler Company Model 911, or a comparable product by one of the following:
 - a. Armstrong International, Inc.
 - b. Leonard Valve Company.
 - c. Powers; a Watts Industries Co.
 - d. Symmons Industries, Inc.
2. Standard: ASSE 1016, thermostatically controlled water tempering valve.
3. Pressure Rating: 125 psig 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.
8. Tempered-Water Setting: 80°F

B. Primary Thermostatic, Water Mixing Valves:

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. Holby Valve Co., Inc.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company.
 - d. Powers; a Watts Industries Co.
 - e. Symmons Industries, Inc.
2. Standard: ASSE 1017.
3. Pressure Rating: 125 psig.
4. Type: Exposed-mounting, thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threaded union inlets and outlet.
7. Accessories: Manual temperature control, check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Valve Pressure Rating: 125 psig minimum, unless otherwise indicated.
9. Tempered-Water Setting: 120°F
10. Valve Finish: Rough bronze.
11. Piping Finish: Copper

C. Manifold, Thermostatic, Water Mixing-Valve Assemblies:

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. Holby Valve Co., Inc.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company.

- d. Powers; a Watts Industries Co.
- e. Symmons Industries, Inc.
- 2. Description: Factory-fabricated, cabinet-type, thermostatically controlled, water mixing-valve assembly in two or three-valve parallel arrangement.
- 3. Large-Flow Parallel: Thermostatic, water mixing valve and downstream-pressure regulator with pressure gages on inlet and outlet.
- 4. Intermediate-Flow Parallel: Thermostatic, water mixing valve and downstream-pressure regulator with pressure gages on inlet and outlet.
- 5. Small-Flow Parallel: Thermostatic, water mixing valve.
- 6. Thermostatic Mixing Valves: Comply with ASSE 1017. Include check stops on hot- and cold-water inlets and shutoff valve on outlet.
- 7. Water Regulator(s): Comply with ASSE 1003. Include pressure gage on inlet and outlet.
- 8. Pressure Rating: 125 psig minimum unless otherwise indicated.
- 9. Cabinet: Factory fabricated, stainless steel, for recessed mounting and with hinged, stainless-steel door.
- 10. Selected Large-Flow, Tempered-Water Valve Size.
- 11. Tempered-Water Setting.
- 12. Unit Tempered-Water Design Flow Rate.
- 13. Unit Minimum Tempered-Water Design Flow Rate.
- 14. Selected Unit Flow Rate at 45-psig Pressure Drop.
- 15. Unit Pressure Drop at Design Flow Rate.
- 16. Unit Tempered-Water Outlet Size: end connection.
- 17. Unit Hot- and Cold-Water Inlet Size: end connections.
- 18. Thermostatic Mixing Valve and Water Regulator Finish: Polished, chrome plated.
- 19. Piping Finish: Chrome plated.

2.8 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

- 1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
- 2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
- 3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
- 4. Screen: Stainless steel with round perforations, unless otherwise indicated.
- 5. Perforation Size:
 - a. Strainers NPS 2 and Smaller: 0.033 inch.
 - b. Strainers NPS 2-1/2 to NPS 4: 0.062 inch.
- 6. Drain: Factory-installed, hose-end drain valve.

2.9 WASHING MACHINE OUTLET BOXES (not used)

A. Clothes Washer Outlet Boxes:

- 1. Mounting: Recessed.

2. Material and Finish: Enameled-steel or epoxy-painted-steel or box and faceplate.
3. 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.
4. Supply Shutoff Fittings: NPS 1/2 gate, globe, or ball valves and NPS 1/2 copper, water tubing.
5. Drain: NPS 2 standpipe and P-trap for direct waste connection to drainage piping.
6. Inlet Hoses: Two 60-inch-long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
7. Drain Hose: One 48-inch-long, rubber household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes:

1. Mounting: Recessed.
2. Material and Finish: Enameled-steel or epoxy-painted-steel or Stainless-steel box and faceplate.
3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
4. Supply Shutoff Fitting: NPS 1/2 gate, globe, or ball valve and NPS 1/2 copper, water tubing.

2.10 HOSE BIBBS

A. Interior Mechanical Room Application:

1. Available Manufacturers:
 - a. Watts.
 - b. Nibco.
 - c. Chicago.
2. Standard: ASME A112.18.1 for sediment faucets.
3. Body Material: Bronze.
4. Seat: Bronze, replaceable.
5. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
6. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
7. Pressure Rating: 125 psig.
8. Vacuum Breaker: Integral, drainable, hose-connection vacuum breaker complying with ASSE 1011.
9. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
10. Operation for Equipment Rooms: Wheel handle or operating key.
11. Include operating key with each operating-key hose bibb.

B. Interior Toilet Room Application:

1. Available Manufacturers:
 - a. Woodford Manufacturing.
 - b. Chicago Faucet.

2. Body: Bronze or brass with integral mounting flange.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 3/4 threaded or solder-joint inlet.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish: chrome or nickel plated.
9. Operation: Wheel handle or operating key.
10. Include operating key with each operating-key hose bibb.

2.11 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze or Chrome plated.
9. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
10. Nozzle and Wall-Plate Finish: Polished nickel bronze in public area, Rough bronze in utility rooms.
11. Operating Keys(s): One with each wall hydrant.

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

1. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Casing and Operating Rods: Of length required to match wall thickness. Include wall clamps.
5. Inlet: NPS 3/4 or NPS 1.
6. Outlet: Concealed.
7. Box: Deep, flush mounted with cover.
8. Box and Cover Finish: Polished nickel bronze in exposed public area, or Chrome plated.
9. 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.
10. Operating Key(s): One with each wall hydrant.

C. Vacuum Breaker Wall Hydrants:

- 1.
2. Standard: ASSE 1019, Type A or Type B.
3. Type: Freeze-resistant, automatic draining with integral air-inlet valve.
4. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.
5. Pressure Rating: 125 psig.
6. Operation: Loose key or wheel handle.
7. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
8. Inlet: NPS 1/2 or NPS 3/4.
9. Outlet: Exposed with garden-hose thread complying with ASME B1.20.7.

2.12 DRAIN VALVES

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

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

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

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

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

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

D. Stop-and-Waste Drain Valves:

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

2.13 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Available Manufacturers:
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. PPP Inc.
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
 - f. Jay R. Smith.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Stainless steel construction with metal bellows, pre-charged.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.14 AIR VENTS

A. Bolted-Construction Automatic Air Vents:

1. Body: Bronze.
2. Pressure Rating and Temperature: 125-psig minimum pressure rating at 140 deg F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded-Construction Automatic Air Vents:

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

2.15 TRAP-SEAL PRIMER VALVES

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

1. PPP Inc Model P-2 with Distribution Unit DU-2 or a comparable product by one of the following:
 - a. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Div.
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.
4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.16 TRAP-SEAL PRIMER SYSTEMS

- A. Trap-Seal Primer Systems:
 1. Standard: ASSE 1044.
 2. Piping: NPS 3/4, ASTM B 88, Type L; copper, water tubing.
 3. Cabinet: Recessed-mounted steel box with stainless-steel cover.
 4. 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.
 5. Vacuum Breaker: ASSE 1001.
 6. Number Outlets: Four.
 7. Size Outlets: NPS 1/2.

2.17 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Flex Pression Ltd.
 2. Flex-Hose Co., Inc.
 3. Metraflex Company (The).
 4. Universal Metal Hose.
- B. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 1. Working-Pressure Rating: Minimum 200 psig.
 2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
 3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

- C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
 - 1. Working-Pressure Rating: Minimum 200 psig.
 - 2. End Connections NPS 2 and Smaller: Threaded steel-pipe nipple.
 - 3. End Connections NPS 2-1/2 and Larger: Flanged steel nipple.

PART 3 - EXCUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install balancing valves in locations where they can easily be adjusted.
- C. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install thermometers and water regulators if specified.
- D. Install Y-pattern strainers for water on supply side of each control valve, solenoid valve, and pump, and where indicated on Drawings.
- E. Install water hammer arresters in water piping according to PDI-WH 201.
- F. Install air vents at high points of water piping.
- G. Install supply-type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.
- H. 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 brakes are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- I. All valves, fittings and specialties shall have a pressure class rating that exceeds the pressure of the system it is installed in.

3.2 CONNECTIONS

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

3.3 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: 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. Double-check, backflow-prevention assemblies.
 - 5. Carbonated-beverage-machine backflow preventers.
 - 6. Dual-check-valve backflow preventers.
 - 7. Reduced-pressure-detector, fire-protection, backflow-preventer assemblies.
 - 8. Double-check, detector-assembly backflow preventers.
 - 9. Water pressure-reducing valves.
 - 10. Calibrated balancing valves.
 - 11. Primary, thermostatic, water mixing valves.
 - 12. Manifold, thermostatic, water mixing-valve assemblies.
 - 13. Photographic-process, thermostatic, water mixing-valve assemblies.
 - 14. Primary water tempering valves.
 - 15. Outlet boxes.
 - 16. Hose stations.
 - 17. Supply-type, trap-seal primer valves.
 - 18. 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 Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

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

- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.5 ADJUSTING

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

END OF SECTION

SECTION 22 13 16
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. Pipe, tube, and fittings.
- 2. Specialty pipe fittings.
- 3. Encasement for underground metal piping.

- B. Related Requirements:

- 1. Section 221313 "Facility Sanitary Sewers" for sanitary sewerage piping and structures outside the building.
- 2. Section 221329 "Sanitary Sewerage Pumps" for effluent and sewage pumps.

1.3 SUBMITTALS

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

- B. Field quality-control reports.

- C. 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

1.4 QUALITY ASSURANCE

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

1.5 PROJECT CONDITIONS

- A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
 - 1. Notify Construction Manager, Owner 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 Construction Manager's, Owner'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: 300-foot head of water
 - 2. Waste, Force-Main Piping: 100 psig.

2.2 PIPING MATERIALS

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

2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.
- C. CISPI, Hubless-Piping Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ANACO-Husky.
 - b. Dallas Specialty & Mfg. Co.
 - c. MIFAB, Inc.
 - d. Tyler Pipe.
 - 2. Standards: ASTM C 1277 and CISPI 310.

3. Description: Stainless-steel corrugated shield with stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- D. Heavy-Duty, Hubless-Piping Couplings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ANACO-Husky.
 - b. Dallas Specialty & Mfg. Co.
 - c. MIFAB, Inc.
 - d. Tyler Pipe.
 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.
- E. Cast-Iron, Hubless-Piping Couplings:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ANACO-Husky.
 - b. Dallas Specialty & Mfg. Co.
 - c. MIFAB, Inc.
 - d. Tyler Pipe.
 2. Standard: ASTM C 1277.
 3. Description: Two-piece ASTM A 48/A 48M, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.
- F. No Hub Fitting Restraints:
1. Basis-of-Design Product: Subject to compliance with requirements, provide Holdrite: 117 Series No Hub Fitting Restraints or comparable
 2. Description: CISPI Designation 301-12, large diameter no-hub cast iron fittings, 4" and over in size, shall be provided with supplemental support to minimize the risk of joints separation under high thrust conditions. Auxiliary restraint products used shall be manufactured assemblies with thrust pressure rating adequate for the specific installation. Field devised methods and materials shall not be used to accomplish this application solution.
- 2.4 DUCTILE-IRON, GRAVITY SEWER PIPE AND FITTINGS
- A. Pipe: ASTM A 746, for push-on joints.
 - B. Standard Fittings: AWWA C110/A21.10, ductile or gray iron, for push-on joints.
 - C. Compact Fittings: AWWA C153/A21.53, ductile iron, for push-on joints.

- D. Gaskets: AWWA C111/A21.11, rubber.

2.5 DUCTILE-IRON, PRESSURE PIPE AND FITTINGS

A. Mechanical-Joint Piping:

1. Pipe: AWWA C151/A21.51, with bolt holes in bell.
2. Standard Fittings: AWWA C110/A21.10, ductile or gray iron, with bolt holes in bell.
3. Compact Fittings: AWWA C153/A21.53, with bolt holes in bells.
4. Glands: Cast or ductile iron; with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
5. Gaskets: AWWA C111/A21.11, rubber, of shape matching pipe, fittings, and glands

2.6 PRESSURE-TYPE PIPE COUPLINGS

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

1. Cascade Waterworks Mfg. Co.
2. Dresser, Inc.
3. Jay R. Smith Mfg. Co.
4. JCM Industries, Inc.
5. Victaulic Company.

- B. Tubular-Sleeve Couplings: AWWA C219, with center sleeve, gaskets, end rings, and bolt fasteners.
- C. Metal, bolted, sleeve-type, reducing or transition coupling; for joining underground pressure piping. Include 200-psig minimum pressure rating and ends of same sizes as piping to be joined.
- D. Center-Sleeve Material: Stainless steel or Ductile iron.
- E. Gasket Material: Natural or synthetic rubber.
- F. Metal Component Finish: Corrosion-resistant coating or material

2.7 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
- B. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.
- C. Hard Copper Tube: ASTM B 88, Type L and Type M, water tube, drawn temper.
- D. Soft Copper Tube: ASTM B 88, Type L, water tube, annealed temper.

E. Copper Pressure Fittings:

1. Copper Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

F. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.

1. Flange Gasket Materials: ASME B16.21, full-face, flat, nonmetallic, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
2. Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

G. Solder: ASTM B 32, lead free with ASTM B 813, water-flushable flux.

2.8 SPECIALTY PIPE FITTINGS

A. Non-pressure Transition Couplings:

1. General Requirements: Fitting or device for joining piping with small differences in OD's or of different materials. Include end connections same size as and compatible with pipes to be joined.
2. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
3. Unshielded, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1173.
 - b. Description: Elastomeric, sleeve-type, reducing or transition pattern. Include shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - c. Sleeve Materials:
 - 1) For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - 2) For Concrete Pipes: ASTM C 443, rubber.
 - 3) For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 4) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - 5) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
4. Shielded, Nonpressure Transition Couplings:
 - a. Standard: ASTM C 1460.
 - b. Description: Elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Ring-Type, Flexible Couplings:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Fernco Inc.
 - b. Logan Clay Pipe.
 - c. Mission Rubber Company; a division of MCP Industries, Inc.
2. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

C. Dielectric Fittings:

1. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
2. Dielectric Unions:
 - 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) Capitol Manufacturing Company.
 - 2) Hart Industries International, Inc.
 - 3) Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 4) Wilkins; a Zurn company.
 - 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.
3. Dielectric Nipples:
 - 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) Grinnell Mechanical Products.
 - 2) Precision Plumbing Products, Inc.
 - 3) Victaulic Company.
 - b. Description:
 - 1) Electroplated steel nipple complying with ASTM F 1545.
 - 2) Pressure Rating: 300 psig at 225 deg F.
 - 3) End Connections: Male threaded or grooved.
 - 4) Lining: Inert and noncorrosive, propylene.

2.9 ENCASEMENT FOR UNDERGROUND METAL PIPING

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

2.10 EXPANSION JOINTS AND DEFLECTION FITTINGS

- A. Ductile-Iron, Flexible Expansion Joints:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. EBAA Iron, Inc.
 - b. Romac Industries, Inc.
 - c. Star Pipe Products.
 - 2. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig minimum working pressure and for offset and expansion indicated.
- B. Ductile-Iron Expansion Joints:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Dresser, Inc.
 - b. EBAA Iron, Inc.
 - c. JCM Industries, Inc.
 - d. Smith-Blair, Inc.; a Sensus company.
 - 2. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for 250-psig minimum working pressure and for expansion indicated.
- C. Ductile-Iron Deflection Fittings:
 - 1. Description: Compound coupling fitting with ball joint, flexing section, gaskets, and restrained-joint ends complying with AWWA C110/A21.10 or AWWA C153/A21.53. Include rating for 250-psig minimum working pressure and for up to 15 degrees of deflection.

2.11 BACKWATER VALVES

A. Cast-Iron Backwater Valves:

1. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Watts; a Watts Water Technologies company.
 - d. Zurn Industries, LLC.
3. Horizontal type; with swing check valve and hub-and-spigot ends.
4. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
5. Terminal type; with bronze seat, swing check valve, and hub inlet.

2.12 CLEANOUTS

A. Cast-Iron Cleanouts:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.
 - c. Watts Water Technologies, Inc.
 - d. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
2. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
3. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

PART 3 - EXECUTION

3.1 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, and other design considerations. Install piping as indicated unless deviations to layout are approved on coordination drawings.

- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- K. Lay buried building 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.
- L. Install soil and waste drainage and vent piping at the following minimum slopes unless otherwise indicated:
 - 1. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
 - 2. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- M. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- N. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."
- O. Install engineered soil and waste and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
 2. Hubless, Single-Stack Drainage System: Comply with ASME B16.45 and hubless, single-stack aerator fitting manufacturer's written installation instructions.
 3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.
- P. Install underground, ductile-iron, force-main piping according to AWWA C600.
1. Install buried piping inside building between wall and floor penetrations and connection to sanitary sewer piping outside building with restrained joints.
 2. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
 3. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
- Q. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
1. Install encasement on piping according to ASTM A 674 or AWWA C105/A 21.5.
- R. Install force mains at elevations indicated
- S. Plumbing Specialties:
1. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers in sanitary drainage gravity-flow piping. Install cleanout fitting with closure plug inside the building in sanitary drainage force-main piping. Comply with requirements for cleanouts specified in Division 22 Section "Sanitary Waste Piping Specialties."
 2. Install drains in sanitary drainage gravity-flow piping. Comply with requirements for drains specified in Division 22 Section "Sanitary Waste Piping Specialties."
 3. Install backwater valves in sanitary waster gravity-flow piping.
 - a. Comply with requirements for backwater valves specified in Section 221319 "Sanitary Waste Piping Specialties."
- T. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 22 Section "Sleeves and Sleeve Seals for Plumbing Piping."

- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 22 Section "Escutcheons for Plumbing Piping."

3.2 PIPE 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. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- C. 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.
- D. Grooved Joints: Cut groove ends of pipe according to AWWA C606. Lubricate and install gasket over ends of pipes or pipe and fitting. Install coupling housing sections, over gasket, with keys seated in piping grooves. Install and tighten housing bolts.
- E. Flanged Joints: Align bolt holes. Select appropriate gasket material, size, type, and thickness. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Torque bolts in cross pattern.
- F. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
1. Use non-pressure flexible couplings where required to join gravity-flow, non-pressure sewer piping unless otherwise indicated.
 - a. Shielded flexible couplings for pipes of same or slightly different OD.
 - b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
 - c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
 2. Use pressure pipe couplings for force-main joints.
- G. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105/A21.5:
1. Hubless cast-iron soil pipe and fittings.
 2. Ductile-iron pipe and fittings.
 3. Expansion joints and deflection fittings.

- H. Install No Hub Fitting Restraints on all piping 4 inch and over in size, shall be provided with supplemental support to minimize the risk of joints separation under high thrust conditions. Auxiliary restraint products used shall be manufactured assemblies with thrust pressure rating adequate for the specific installation. Field devised methods and materials shall not be used to accomplish this application solution

3.3 CLEANOUT INSTALLATION

- A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
 - 1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
 - 2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
 - 3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
 - 4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads. H-50
- B. Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches Insert dimensions deep. Set with tops 1 inch above surrounding grade.
- C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

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.
- 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 nipples.
 - 4. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.5 VALVE INSTALLATION

- A. Comply with requirements in Section 220523. General-duty valve installation requirements.
- B. Shutoff Valves:

1. Install shutoff valve on each sewage pump discharge.
 2. Install gate or full-port ball valve for piping NPS 2 and smaller.
 3. Install gate valve for piping NPS 2-1/2 and larger.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
1. Horizontal Piping: Horizontal backwater valves. Use normally closed type unless otherwise indicated.
 2. Floor Drains: Drain outlet backwater valves unless drain has integral backwater valve.
 3. Install backwater valves in accessible locations.
 4. Comply with requirements for backwater valve specified in Section 221319 "Sanitary Waste Piping Specialties."

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hanger and support devices and installation specified in Division 22 Section "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. Install stainless-steel pipe support clamps for vertical piping in corrosive environments.
 4. Vertical Piping: MSS Type 8 or Type 42, clamps.
 5. 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.
 6. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 7. Base of Vertical Piping: MSS Type 52, spring hangers.
- B. Support horizontal piping and tubing within 12 inches of each fitting, valve, and coupling.
- C. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- D. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.

2. NPS 3: 60 inches with 1/2-inch rod.
 3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
 4. NPS 6 and NPS 8: 60 inches with 3/4-inch rod.
 5. NPS 10 and NPS 12: 60 inches with 7/8-inch rod.
 6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.
- E. Install supports for vertical cast-iron soil piping every 15 feet and or at every floor
- F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 84 inches with 3/8-inch rod.
 2. NPS 1-1/2: 108 inches with 3/8-inch rod.
 3. NPS 2: 10 feet with 3/8-inch rod.
 4. NPS 2-1/2: 11 feet with 1/2-inch rod.
 5. NPS 3: 12 feet with 1/2-inch rod.
 6. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 7. NPS 4 and NPS 5: 12 feet with 5/8-inch rod.
 8. NPS 6 and NPS 8: 12 feet with 3/4-inch rod.
 9. NPS 10 and NPS 12: 12 feet with 7/8-inch rod
- G. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
1. NPS 1-1/4: 72 inches with 3/8-inch rod.
 2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
 3. NPS 2-1/2: 108 inches with 1/2-inch rod.
 4. NPS 3 and NPS 5: 10 feet with 1/2-inch rod.
 5. NPS 6: 10 feet with 5/8-inch rod.
 6. NPS 8: 10 feet with 3/4-inch rod
- H. Install supports for vertical copper tubing every 10 feet and at every floor
- 3.7 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 backwater valves 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. Connect force-main piping to the following:
1. Sanitary Sewer: To exterior force main.
 2. Sewage Pump: To sewage pump discharge.
- E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
- F. Make connections according to the following unless otherwise indicated:
1. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment.
 2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3.8 IDENTIFICATION

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

3.9 FIELD QUALITY CONTROL

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

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 6. Prepare reports for tests and required corrective action.
- E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved.
 - a. Expose work that was covered or concealed before it was tested.
 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials.
 - a. Isolate test source and allow to stand for four hours.
 - b. Leaks and loss in test pressure constitute defects that must be repaired.
 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 4. Prepare reports for tests and required corrective action.
- 3.10 CLEANING AND PROTECTION
- A. Clean interior of piping. Remove dirt and debris as work progresses.
 - B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
 - C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.11 PIPING SCHEDULE

- A. Aboveground, soil and waste piping NPS 4 and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy duty hubless-piping couplings; and coupled joints.
 - 3. Copper DWV tube, copper drainage fittings, and soldered joints.
 - 4. Dissimilar Pipe-Material Couplings: Shielded, pressure transition couplings.
- B. Aboveground, soil and waste piping NPS 5 and larger shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 - 3. Galvanized-steel pipe, drainage fittings, and threaded joints.
 - 4. Dissimilar Pipe-Material Couplings: Shielded, pressure transition couplings.
- C. Aboveground, vent piping NPS 4 and smaller shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Copper DWV tube, copper drainage fittings, and soldered joints.
 - a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2: Hard copper tube, Type M; copper pressure fittings; and soldered joints.
 - 3. Dissimilar Pipe-Material Couplings: Shielded, pressure transition couplings.
- D. Aboveground, vent piping NPS 5 and larger shall be any of the following:
 - 1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 - 3. Galvanized-steel pipe, drainage fittings, and threaded joints.
 - 4. Dissimilar Pipe-Material Couplings: Shielded, pressure transition couplings.
- E. Underground, soil, waste, and vent piping NPS 4 and smaller shall be any of the following:
 - 1. Extra heavy class, cast-iron soil piping; gaskets; and gasketed joints.
 - 2. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
 - 3. Dissimilar Pipe-Material Couplings: Shielded, pressure transition couplings.
- F. Underground, soil and waste piping NPS 5 and larger shall be any of the following:
 - 1. Extra heavy class, cast-iron soil piping; gaskets; and gasketed joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, pressure transition couplings.
 - 3. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints

- G. 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.
- H. Aboveground sanitary-sewage force mains NPS 2-1/2 to NPS 6 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. Underground sanitary-sewage force mains NPS 4 and smaller shall be any of the following:
 - 1. Ductile-iron, mechanical-joint piping and mechanical 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.
- J. Underground sanitary-sewage force mains NPS 5 and larger shall be any of the following:
 - 1. Ductile-iron, mechanical-joint piping and mechanical joints.
 - 2. Pressure transition couplings if dissimilar pipe materials.

END OF SECTION

SECTION 22 13 19

SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Backwater valves
 - 2. Cleanouts.
 - 3. Air admittance Valves
 - 4. Roof flashing assemblies.
 - 5. Through-penetration firestop assemblies.
 - 6. Miscellaneous sanitary drainage piping specialties.
 - 7. Flashing Materials
 - 8. Solids interceptors.
- B. Related Sections include the following:
 - 1. Division 22 Section "Sanitary Waste and Vent Piping".

1.3 DEFINITIONS

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

1.4 SUBMITTALS

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

- B. Shop Drawings: Show fabrication and installation details for frost-resistant vent terminals.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

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 BACKWATER VALVES

- A. Horizontal, Cast-Iron Backwater Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. MIFAB, Inc.
 - d. Watts; a Watts Water Technologies company.
 - e. Zurn Industries, LLC.
 - 2. Standard: ASME A112.14.1.

3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled, or field modified to hang open for airflow unless subject to backflow condition.
8. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain-Outlet Backwater Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Watts; a Watts Water Technologies company.
 - d. Zurn Industries, LLC.
2. Size: Same as floor drain outlet.
3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

2.3 CLEANOUTS

A. Cast Iron Exposed Cleanouts:

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

B. Cast Iron Exposed Floor Cleanouts:

1. Available Manufacturers:
 - a. Josam Company; Josam Div.
 - b. Watts Drainage Products Inc.
 - c. Zurn Plumbing Products Group; Light Commercial Operation.
 - d. Wade
 - e. Jay R. Smith.
 2. Standard: ASME A112.36.2M.
 3. Size: Same as connected branch.
 4. Type: Threaded, adjustable housing.
 5. Body or Ferrule: Cast iron.
 6. Clamping Device: Required.
 7. Outlet Connection: Threaded.
 8. Closure: Brass plug with tapered threads.
 9. Adjustable Housing Material: Cast iron.
 10. Frame and Cover Material and Finish: Nickel-bronze, copper alloy.
 11. Frame and Cover Shape: Round.
 12. Top Loading Classification: Medium Duty.
 13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
 14. Standard: ASME A112.3.1.
 15. Size: Same as connected branch.
 16. Housing: Stainless steel.
 17. Closure: Stainless steel with seal.
 18. Riser: Stainless-steel drainage pipe fitting to cleanout.
- C. Cast-Iron Wall Cleanouts:
1. Available Manufacturers:
 - a. Josam Company; Josam Div.
 - b. MIFAB, Inc.
 - c. Watts Drainage Products Inc.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
 - e. Wade
 - f. Jay R. Smith
 2. Standard: ASME A112.36.2M. Include wall access.
 3. Size: Same as connected drainage piping.
 4. Body: Hub-and-spigot, cast-iron soil pipe T-branch, or Hubless, cast-iron soil pipe test tee as required to match connected piping.
 5. Closure: cast-iron plug.
 6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
 7. Wall Access: Round, flat, chrome-plated brass or stainless-steel cover plate with screw.
 8. Wall Access: Round, nickel-bronze, copper-alloy, or stainless-steel wall-installation frame and cover.

2.4 AIR-ADMITTANCE VALVES

A. Fixture Air-Admittance Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ayrlett, LLC.
 - b. Durgo, Inc.
 - c. Oatey.
 - d. ProSet Systems Inc.
2. Standard: ASSE 1051, Type A for single fixture or Type B for branch piping.
3. Housing: Plastic.
4. Operation: Mechanical sealing diaphragm.
5. Size: Same as connected fixture or branch vent piping.

B. Stack Air-Admittance Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ayrlett, LLC.
 - b. Durgo, Inc.
 - c. Oatey.
 - d. ProSet Systems Inc.
2. Standard: ASSE 1050 for vent stacks.
3. Housing: Plastic.
4. Operation: Mechanical sealing diaphragm.
5. Size: Same as connected stack vent or vent stack.

C. Wall Box for Air-Admittance Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Ayrlett, LLC.
 - b. Durgo, Inc.
 - c. Oatey.
 - d. ProSet Systems Inc.
2. Description: White plastic housing with white plastic grille, made for recessed installation. Include bottom pipe connection and space to contain one air-admittance valve.
3. Size: About 9 inches wide by 8 inches high by 4 inches deep

2.5 FLOOR DRAINS

A. Cast-Iron Floor Drains:

1. Available manufacturers:

- a. Josam Company; Josam Div.
 - b. Tyler Pipe; Wade Div.
 - c. Watts Drainage Products Inc.
 - d. Zurn Plumbing Products Group; Light Commercial Operation.
 - e. Jay R. Smith
2. Standard: ASME A112.6.3.
 3. Pattern: Floor drain.
 4. Body Material: Gray iron.
 5. Anchor Flange: Required.
 6. Clamping Device: Required.
 7. Sediment Bucket: Not required for finished areas.
 8. Top or Strainer Material: Nickel bronze.
 9. Top Shape: Round.
 10. Top Loading Classification: Light Duty.
 11. Trap Material: Cast iron.
 12. Trap Pattern: Standard P-trap.

2.6 ROOF FLASHING ASSEMBLIES (all architectural specifications shall supersede this paragraph).

A. Roof Flashing Assemblies:

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. Acorn Engineering Company; Elmdor/Stoneman Div.
 - b. Thaler Metal Industries Ltd.

B. Description: Manufactured assembly made of 4.0-lb/sq. ft., 0.0625-inch-thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

1. Open-Top Vent Cap: Without cap.
2. Low-Silhouette Vent Cap: With vandal-proof vent cap.
3. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.7 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ProSet Systems Inc.
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.

4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray-iron, hubless-pattern, wye branch with neoprene O-ring at base and gray-iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.8 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564 rubber gaskets.
2. Size: Same as connected waste piping.

B. Deep-Seal Traps:

1. Description: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
 - a. NPS 2: 4-inch-minimum water seal.
 - b. NPS 2-1/2 and Larger: 5-inch-minimum water seal.

C. 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 side inlet.

D. 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.

E. Sleeve Flashing Device:

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

F. Stack Flashing Fittings:

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

G. Vent Caps:

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

H. Frost-Resistant Vent Terminals:

1. Description: Manufactured or shop-fabricated assembly constructed of copper, lead-coated copper, or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

I. Expansion Joints:

1. Standard: ASME A112.6.4.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.9 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft. thickness.
2. Vent Pipe Flashing: 8 oz./sq. ft. thickness.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.10 SOLIDS INTERCEPTORS

A. Solids Interceptors:

1. Jay R. Smith Model 8710 or a comparable product by one of the following:
 - a. Josam Company; Josam Div.
 - b. Tyler Pipe; Wade Div.
 - c. Watts Drainage Products Inc.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Type: Factory-fabricated interceptor made for removing and retaining sediment from wastewater.
3. Body Material: Cast iron or steel.
4. Interior Separation Device: Screens.
5. Interior Lining: Corrosion-resistant enamel.
6. Mounting: Above floor.

2.11 CLAY INTERCEPTOR

A. Solids Interceptors:

1. Jay R. Smith Model 871 T0150 or a comparable product by one of the following:
 - a. Josam Company; Josam Div.
 - b. Tyler Pipe; Wade Div.
 - c. Watts Drainage Products Inc.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Type: Factory-fabricated interceptor made for removing and retaining sediment from wastewater.
3. Body Material: ABS
4. Interior Separation Device: Screens.
5. 15 gpm
6. 1 ½" inlet / outlet
7. Quick removal latches for top access sediment strainer removal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install backwater valves in building drain piping.
 1. For interior installation, provide cleanout deck plate flush with floor and centered over backwater valve cover, and of adequate size to remove valve cover for servicing.

- C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- F. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches 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.
 - 3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- G. Install through-penetration firestop assemblies in plastic conductors and stacks at floor penetrations.
- H. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- I. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- J. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- K. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

- L. 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.
- M. Install air-gap fittings on indirect-waste piping discharge into sanitary drainage system.
- N. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- O. Install vent caps on each vent pipe passing through roof.
- P. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- Q. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- R. Install wood-blocking reinforcement for wall-mounting-type specialties.
- S. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- T. All valves, fittings and specialties shall have a pressure class rating that exceeds the pressure of the system it is installed in.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping.
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.3 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
 - 2. Copper Sheets: Solder joints of copper sheets.

- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Interceptors.
- 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.
 - 1. Nameplates and signs are specified in Section 220553 "Identification for Plumbing Piping and Equipment."

3.5 FIELD QUALITY CONTROL

- A. 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

SECTION 22 13 19.13

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. Cast iron floor drains.
 - 2. Stainless steel floor drains
 - 3. Cast iron floor sinks
 - 4. Stainless steel floor sinks
 - 5. Trench drains.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 DRAIN ASSEMBLIES

- A. Sanitary drains shall bear label, stamp, or other markings of specified testing agency.

- B. Comply with NSF 14 for plastic sanitary piping specialty components.
- C. All sanitary floor drains shall be provided with pro-vent trap guard size for each floor drain. Product shall be tested in accordance with ASSE 1072 test standard for ANSI/ASME A112.6.3
- D. Cast-Iron Floor 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; a Watts Water Technologies company.
 - d. Zurn Industries, LLC.
 - 2. Standard: ASME A112.6.3.
 - 3. Pattern: Floor drain.
 - 4. Body Material: Gray iron.
 - 5. Seepage Flange: Required.
 - 6. Anchor Flange: Required.
 - 7. Clamping Device: Required.
 - 8. Outlet: Bottom or Side coordinate with filed conditions.
 - 9. Backwater Valve: Not required unless indicated on drawings.
 - 10. Coating on Interior and Exposed Exterior Surfaces: For laboratory applications Acid-resistant enamel.
 - 11. Sediment Bucket:
 - 12. Top or Strainer Material: Gray cast iron in mechanical equipment rooms, polished nickel bronze in all finished areas.
 - 13. Top Shape: Round or Square as scheduled
 - 14. Dimensions of Top or Strainer: Refer to schedule.
 - 15. Top Loading Classification: Heavy Duty 20 for any application subject to traffic like parking or repair garages.
 - 16. Funnel: Not required unless specified on plan or in schedule.
 - 17. Inlet Fitting: Gray iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
 - 18. Trap Material: Cast iron.
 - 19. Trap Pattern: Standard P-trap.
 - 20. Trap Features: Cleanout, Trap-seal primer valve drain connection where indicated in schedule.
- E. Stainless-Steel Floor Drains, ASME A112.3.1:
 - 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; a Watts Water Technologies company.
 - d. Zurn Industries, LLC.
 - 2. Outlet: Bottom or Side.

3. Top or Strainer Material: Stainless steel.
4. Top Shape: Round or Square.
5. Dimensions of Top or Strainer:
6. Seepage Flange: Required.
7. Anchor Flange: Required.
8. Clamping Device: Required.
9. Trap-Primer Connection: Required where indicated on plan
10. Trap Material: Stainless steel.
11. Trap Pattern: Standard P-trap.

2.2 FLOOR SINKS

A. Cast-Iron Floor Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Watts; a Watts Water Technologies company.
 - d. Zurn Industries, LLC.
3. Standard: ASME A112.6.7.
4. Pattern: Funnel floor drain.
5. Body Material: Cast iron.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom, no-hub connection.
9. Coating on Interior Surfaces: Not required
10. Sediment Bucket.
11. Internal Strainer: Flat.
12. Internal Strainer Material: Aluminum.
13. Top Grate Material: looser hinged.
14. Top of Body and Grate Finish: Nickel bronze.
15. Top Shape: Round or Square.
16. Dimensions of Top Grate: as per plan.
17. Top Loading Classification.
18. Funnel: Required.

B. Stainless-Steel Floor Sinks, ASME A112.6.7:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2.
 - a. Jay R. Smith Mfg. Co.
 - b. Josam Company.
 - c. Watts; a Watts Water Technologies company.
 - d. Zurn Industries, LLC.
3. Standard: ASME A112.6.7.
4. Pattern: Funnel floor drain.
5. Body Material: Stainless steel.

6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom, no-hub connection.
9. Sediment Bucket.
10. Internal Strainer: Dome or Flat.
11. Internal Strainer Material: Stainless steel.
12. Top Grate Material: loose or hinged.
13. Top of Body and Grate Finish: Satin nickel or Stainless steel.
14. Top Shape: Round or Square.
15. Dimensions of Top Grate: refer to plan and schedule.
16. Top Loading Classification: No traffic.
17. Funnel: Required.

2.3 TRENCH DRAINS

A. Trench 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. MIFAB, Inc.
 - d. Tyler Pipe; a subsidiary of McWane Inc.
 - e. Watts; a Watts Water Technologies company.
 - f. Zurn Industries, LLC.
2. Standard: ASME A112.6.3 for trench drains.
3. Material: Ductile or gray iron.
4. Flange: Anchor and Seepage.
5. Clamping Device: Required.
6. Outlet: Bottom, End or Side coordinate with field conditions
7. Grate Material: Stainless steel.
8. Grate Finish: Brushed.
9. Dimensions of Frame and Grate: refer to plan and schedule
10. Top Loading Classification: Extra Heavy Duty. H-20
11. Trap Material: Cast iron.
12. Trap Pattern: Standard P-trap.

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.
- D. Install FRP channel drainage system components on support devices, so that top will be flush with adjacent surface.
- E. Install plastic channel drainage system components on support devices, so that top will be flush with adjacent surface.
- F. Install open drain fittings with top of hub 2 inches above floor.
- 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

SECTION 22 14 29

SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Submersible sump pumps.
 - 2. Sump-pump basin covers.
 - 3. Elevator Oil Minder Sump Pump.

- B. Related Section:

1.3 SUBMITTALS

- A. Product Data: For each type of pump, motor, control panel, basin cover. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

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. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.

- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

PART 2 - PRODUCTS

2.1 SUBMERSIBLE SUMP PUMPS

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

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. Federal Pumps
 - b. Bell & Gossett Domestic Pump; ITT Corporation.
 - c. Goulds Pumps; ITT Corporation.
 - d. Grundfos Pumps Corp.
 - e. Liberty Pumps.
 - f. Stancor, Inc.
2. Description: Factory-assembled and -tested sump-pump unit.
3. Pump Type: Submersible, end-suction, single-stage, close-coupled, overhung-impeller, centrifugal sump pump as defined in HI 1.1-1.2 and HI 1.3.
4. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
5. Seal: Mechanical.
6. 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.
7. A name-plate showing the serial number, discharge GPM and Head of each pump shall be attached to the respective pump. The necessary wiring and controlling devices will be furnished and installed complete under the Electrical Division, unless otherwise specified.
8. Controls:
 - a. Duplex Sump pump shall be controlled by a pedestal mounted float switch with built in alternator, Square D Company Class 9038 type AW-1 in a NEMA Type 4 watertight and dust-tight enclosure that is actuated by a minimum 7" stainless steel ball float and stainless steel rod guided above and below floor plate of pump.
 - b. Provide a high-water alarm consisting of an auxiliary pedestal mounted single pole float switch equipped with a pedestal guide, gas-tight stainless steel rod and minimum 7" stainless steel ball float. Should the high-water alarm be activated, a warning signal shall be delivered to the Indicator Panel. With electric bell; 120-V ac, with transformer and contacts for remote alarm bell.
 - c. Switch Type: Pedestal-mounted float switch with float rods and rod buttons.

- d. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
- 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.

2.2 SUMP PUMP CAPACITIES AND CHARACTERISTICS

- 1. Refer to Drawing P-001 for unit specifications and capacities.

2.3 SUMP-PUMP BASIN COVERS

- A. Angle frame and sump pit cover plate shall be provided and installed by the Plumbing Contractor. The Contractor shall coordinate the sump pit cover with the pump supplier such that it has all required openings for pumps and piping with openings having gaskets, seals, and bushings such as: access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.
 - 1. Reinforcement: Steel or cast iron, capable of supporting foot traffic.

2.4 SUMP PUMP (ELEVATOR PIT)

- A. Provide a Stancor pump in the elevator pit. Refer to Drawing P-001 for pump specifications and capacities.
- B. Provide check valve on pump discharge. Provide 5 ft. extra cable rolled and clamped to allow for removal of pump from pit. Provide a local disconnect switch, and pump control panel where indicated on the drawings.
- C. Pump Casing: Cast iron, with strainer inlet, legs that elevate pump to permit flow into impeller, and vertical discharge for piping connection.
- D. Seal: Mechanical.
- E. 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.
- F. A name-plate showing the serial number, discharge GPM and Head of each pump shall be attached to the respective pump. The necessary wiring devices will be

furnished and installed complete under the Electrical Division, unless otherwise specified.

G. Controls:

1. Simplex sump pump shall be controlled by a pedestal mounted float switch that is actuated by a minimum 7" stainless steel ball float and stainless steel rod guided above and below floor plate of pump. Or a cable mounted floats for on off.
2. Provide a high-water alarm consisting of an auxiliary pedestal mounted single pole float switch, equipped with a pedestal guide, (or cable mounted float) gas-tight stainless steel rod and minimum 7" stainless steel ball float. Should the high-water alarm be activated, a warning signal shall be delivered to the Indicator Panel. With electric bell; 120-V ac, with transformer and contacts for remote alarm bell. The contacts shall be wired to the building BMS. Upon contact closure an alarm signal shall be initiated on the BMS which indicates high water and which elevator pit is being served. (ie. Main elevator bank or sidewalk lift elevator)
3. Switch Type: float switch with float rods and rod buttons. Or cable mounted.
4. Float Guides: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches.
5. Control Panel CB 1000;
 - a. Pumps serving non hydraulic elevators shall have pump control panels that are NEMA 4x suitable for pump control with optional dry remote alarm contacts for high water alarm.
 - b. Stanmore model CB 1000. With pump running light, high level alarm, test and silence bottom and H-O-A selector switch.
 - c. Pumps serving hydrolic elevators shall have a Nema 4x control panel 4x suitable for pump control with (2) optional dry remote alarm contacts for high water alarm and oil alarm. Provide stainless steel discriminating oil detector.
 - d. Panel and pump system shall be Stancore oil minder model OM-50SR-ELV , with reset button, silence button RMS connector.
 - e. Provide local disconnect switch for all pump systems.

2.5 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section "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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
- B. Motors for submersible pumps shall be hermetically sealed.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 EXAMINATION

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

3.3 INSTALLATION

- A. Pump Installation Standards: Comply with HI 1.4 for installation of sump pumps.
- B. The Contractor shall have the pump supplier verify the depth of each sump pit so that proper length of shaft shall be supplied.

3.4 CONNECTIONS

- A. Comply with requirements for piping specified in Division 22 Section "Facility Storm Drainage Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Make all required connections of pumps to the piping systems. Use flexible connectors to connect pumps to piping.
- C. Install piping adjacent to equipment to allow service and maintenance.

3.5 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. 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.

3.6 STARTUP SERVICE

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

3.7 ADJUSTING

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

3.8 DEMONSTRATION

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

END OF SECTION

SECTION 22 40 00

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. This Section includes the following conventional plumbing fixtures and related components:
 - 1. Faucets for lavatories and sinks.
 - 2. Flushometers.
 - 3. Toilet seats.
 - 4. Protective shielding guards.
 - 5. Fixture supports.
 - 6. Water closets.
 - 7. Urinals.
 - 8. Lavatories.
 - 9. Commercial sinks.
 - 10. Service sinks.
- B. Related Sections include the following:
 - 1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
 - 2. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.
- D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

- E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
- F. FRP: Fiberglass-reinforced plastic.
- G. PMMA: Polymethyl methacrylate (acrylic) plastic.
- H. PVC: Polyvinyl chloride plastic.
- I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.4 SUBMITTALS

- A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.
- D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" for plumbing fixtures for people with disabilities.
- D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
 - 1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
 - 2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
 - 3. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 4. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
 - 5. Vitreous-China Fixtures: ASME A112.19.2M.
 - 6. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
- H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
 - 1. Faucets: ASME A112.18.1.
 - 2. Hose-Connection Vacuum Breakers: ASSE 1011.
 - 3. Hose-Coupling Threads: ASME B1.20.7.
 - 4. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 - 5. NSF Potable-Water Materials: NSF 61.
 - 6. Pipe Threads: ASME B1.20.1.
 - 7. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
 - 8. Supply Fittings: ASME A112.18.1.
 - 9. Brass Waste Fittings: ASME A112.18.2.
- I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
 - 1. Atmospheric Vacuum Breakers: ASSE 1001.
 - 2. Brass and Copper Supplies: ASME A112.18.1.
 - 3. Manual-Operation Flushometers: ASSE 1037.
 - 4. Plastic Tubular Fittings: ASTM F 409.
 - 5. Brass Waste Fittings: ASME A112.18.2.
 - 6. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.
- J. Comply with the following applicable standards and other requirements specified for miscellaneous components:
 - 1. Floor Drains: ASME A112.6.3.
 - 2. Hose-Coupling Threads: ASME B1.20.7.
 - 3. Off-Floor Fixture Supports: ASME A112.6.1M.
 - 4. Pipe Threads: ASME B1.20.1.
 - 5. Plastic Toilet Seats: ANSI Z124.5.
 - 6. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

- A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
 - a. Structural failures of unit shell.
 - b. Faulty operation of controls, blowers, pumps, heaters, and timers.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 2. Warranty Period for Commercial Applications: One year(s) from date of Substantial Completion.

1.7 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. 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.
 3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
 4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
 5. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

- A. Lavatory Faucets: as specified on contract drawings.

2.2 FLUSHOMETERS: as specified on contract drawings.

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

2.4 FIXTURE SUPPORTS

- 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. Josam Company.
 2. Smith, Jay R. Mfg. Co.
 3. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
 4. Zurn Plumbing Products Group; Specification Drainage Operation.
- B. Water-Closet Supports:
1. Description: Combination carrier designed for accessible or standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.
 2. Support shall be Extra Heavy Duty, rated for 750 lbs.
- C. Urinal Supports:

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

D. Lavatory Supports (for wall-hung lav.):

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

2.5 WATER CLOSETS

A. Water Closets:

1. Refer to Plumbing fixture schedule on contract drawings model as indicated or a comparable product by one of the following:
 - a. Crane Plumbing, L.L.C./Fiat Products.
 - b. Eljer.
 - c. Kohler Co.
 - d. TOTO USA, Inc.

2.6 URINALS

A. Urinals:

1. Refer to Plumbing fixture schedule on contract drawings model as indicated or a comparable product by one of the following:
 - a. Crane Plumbing, L.L.C./Fiat Products.
 - b. Kohler Co.
 - c. Toto USA, Inc.
2. Description: Refer to plumbing fixture schedule on contract drawings.

2.7 LAVATORIES

A. Wall Hung Lavatories:

1. Refer to Plumbing fixture schedule on contract drawings model as indicated or a comparable product by one of the following:
 - a. Eljer.
 - b. Kohler
 - c. Crane Plumbing, L.L.C./Fiat Products.
 - d. Toto USA, Inc.

2. Description: Refer to plumbing fixture schedule on contract drawings.
- B. Countertop Lavatories: Refer to plumbing fixtures schedule on contract drawings.
1. Refer to Plumbing fixture schedule on contract drawings model as indicated or a comparable product by one of the following:
 - a. Eljer.
 - b. Kohler
 - c. Crane Plumbing, L.L.C./Fiat Products.
 - d. Toto USA, Inc.
 2. Refer to architectural specifications for sink and matching solid surface countertop.
 3. The plumbing contractor shall provide the countertop mounted faucet, and all required supplies, drainage piping, drain grid, and trap.

2.8 SERVICE BASINS

- A. Square Service Basins:
1. Refer to Plumbing fixture schedule on contract drawings model as indicated or a comparable product by one of the following:
 - a. Acorn Engineering Company.
 - b. Florestone Products Co., Inc.
 - c. Precast Terrazzo Enterprises, Inc.
 - d. Stern-Williams Co., Inc.
 2. Description: Flush-to-wall, floor-mounting, precast fixture with rim guard.
 - a. Shape: Square, 24x24 inches.
 - b. Height: 10 inches.
 - c. Tiling Flange: On two sides.
 - d. Rim Guard: On front top surfaces.
 3. Faucet: Fiat model 830-AA wall mounted service faucet with vacuum breaker, adjustable wall brace, pail hook, and $\frac{3}{4}$ " hose threads at spout outlet. 4-arm handles on 8" centers.
 4. Accessories
 - a. Drain model #302. Dome strainer with lint basket and NPS 2 outlet.
 - b. Model 889CC - Mop Bracket.
 - c. Model 823AA - 2'-6" length of 5/8" rubber hose with female coupling and Fiat's hose bracket.
 - d. Model MSG-2424 Stainless Steel Wall Guards. Mount to adjacent walls

PART 3 - EXECUTION

3.1 EXAMINATION

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

3.2 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install wall-mounting fixtures with tubular waste piping attached to supports.
- E. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.
- F. Install counter-mounting fixtures in and attached to casework.
- G. Install fixtures level and plumb according to roughing-in drawings.
- H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."
- I. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

- J. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- K. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- L. Install toilet seats on water closets.
- M. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- N. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
- O. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- P. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- Q. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Escutcheons for Plumbing Piping."
- R. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

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

3.4 FIELD QUALITY CONTROL

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

3.5 ADJUSTING

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

3.6 CLEANING

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

3.7 PROTECTION

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

END OF SECTION

SECTION 22 47 16

WATER COOLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes pressure water coolers with bottle filler and related components.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For pressure water coolers to include in maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filter Cartridges: Equal to 10 percent of quantity installed for each type and size indicated, but no fewer than 5 of each.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS (P-5)

- A. Pressure Water Coolers: Wall mounted, wheelchair accessible, with bottle filler, vandal resistant.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Elkay Manufacturing Co.
 - b. Halsey Taylor.
 - c. Haws Corporation.
 - d. Larco Inc.
 - e. Oasis International.
2. Standards:
 - a. Comply with NSF 61 and NSF 372.
 - b. Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant unless otherwise indicated.
 - c. Comply with ICC A117.1.
3. Cabinet: single level with attached cabinets and skirt kit, all stainless steel.
4. Bubbler: One, with adjustable stream regulator.
5. Control: Push button.
6. Bottle Filler: Push-button activation with 20-second automatic shutoff timer. Fill rate 0.5 to 1.5 gpm.
7. Drain: Grid with NPS 1-1/4 tailpiece.
8. Supply: NPS 3/8 with shutoff valve.
9. Ventilation Grille: Stainless steel.
10. Waste Fitting: ASME A112.18.2/CSA B125.2, NPS 1-1/4 brass P-trap.
11. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
12. Cooling System: Electric, with hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.
 - 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.
13. Capacities and Characteristics:
 - a. Cooled Water: 5 gph.
 - b. Ambient-Air Temperature: 90 deg F.
 - c. Inlet-Water Temperature: 80 deg F.
 - d. Cooled-Water Temperature: 50 deg F.

- e. Cooled-Water Storage.
- f. Electrical Characteristics: refer to drawing schedule
- 14. Support: Type I Water or Cooler Carrier Type II Water Cooler Carrier as recommended by the manufacture.
- 15. Water Cooler Mounting Height: Handicapped/elderly according to ICC A117.1.
- 16. Cabinet: All stainless steel integral with drinking fountain water cooler.
- 17. Bottle filler: electronic hands-free activation with 20-second automatic shut-off timer. Fill rate 0.5 to 1.5 gpm.
- 18. Support: Mounting frame for attaching to substrate.

2.2 SUPPORTS

A. Type I Water Cooler Carrier:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. Wade Drains.
 - d. WATTS.
 - e. Zurn Industries, LLC.
- 2. Standard: ASME A112.6.1M.

B. Type II Water Cooler Carrier:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Jay R. Smith Mfg Co; a division of Morris Group International.
 - b. Josam Company.
 - c. Wade Drains.
 - d. WATTS.
 - e. Zurn Industries, LLC.
- 2. Standard: ASME A112.6.1M.

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. Set freestanding pressure water coolers on floor.
- C. Install off-the-floor carrier supports, affixed to building substrate, for wall-mounted fixtures.
- D. Install mounting frames, affixed to building construction, and attach recessed, pressure water coolers, and in-wall bottle filling stations to mounting frames.
- E. Install water-supply piping with shutoff valve on supply to each fixture to be connected to domestic-water distribution piping. Use ball or gate valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Section 220523.12 "Valves for Plumbing Piping" and Section 220523.15
- F. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- G. 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 Section 220518 "Escutcheons for Plumbing Piping."
- H. 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 shutoff valve on water supply to each fixture. Install valve upstream from filter for water cooler. Comply with valve requirements specified in Section 220523.12 "Valves for Plumbing 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.

- B. Adjust pressure water-cooler temperature settings.

3.5 CLEANING

- A. After installing fixture, 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

SECTION 23 05 00

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 RELATED DOCUMENTS

- A. These basic Mechanical Requirements apply to all Division 23 Sections.
- B. The work of this Section consists of providing of all materials, labor and equipment and the like necessary and/or required for the complete execution of all HVAC and related work for this project, as required by the contract documents.

1.2 RELATED DOCUMENTS

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

1.3 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER RESPECTIVE SECTIONS OF THIS DIVISION

- A. Motor starters shall be furnished under this Division. Refer to Specification Section 230513 Common motor requirements for HVAC equipment" for technical information.

1.4 REFERENCES

- A. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers Guides and Standards, latest editions.
- B. SMACNA - Sheet Metal and Air Conditioning Contractors National Association.
- C. ASME - American Society of Mechanical Engineers.
- D. UL - Underwriters Laboratory.
- E. NFPA - National Fire Protection Association.

1.5 REGULATORY REQUIREMENTS

- A. Conform to New York State Building Codes and Energy Code as well as all local codes.
- B. Plumbing: Conform to New York State U.F.P.B.C.

- C. Obtain permits, and request inspections from authority having jurisdiction.
- D. NY State Education Department Facility Guidelines

1.6 QUALITY ASSURANCE

- A. The Contractor shall have the work indicated on the drawings and/or specified in each section performed by vendors or mechanics experienced and skilled in its implantation or by a "Specialist", "Specialty Contractor" or "Specialty Subcontractor" under contractual agreement with the Contractor. These terms mean an individual or firm of established reputation, or, if newly organized, whose personnel have previously established a reputation in the same field, which is regularly engaged in, and which maintains a regular force of workmen skilled in either manufacturing or fabricating items required by the Contract, installing items required by the Contract, or otherwise performing work required by the Contract.
- B. Where the Contract Specifications require installation by a "Specialist," that term shall also be deemed to mean either the manufacturer of the item, an individual or firm licensed by the manufacturer, or an individual or firm who will perform such work under the manufacturer's direct supervision.

1.7 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed arrangement of Work to meet Project conditions, including changes to Work specified in other Sections.

1.8 SCOPE OF WORK

- A. This Contractor shall be responsible for coordinating his work with all other trades.
- B. The Contractor shall provide all materials, labor, equipment, tools, appliances, services, hoisting, scaffolding, supervision and overhead for the furnishing and installing of all mechanical work and related work including but not limited to the following:
 - 1. Geothermal well field, piping, controls
 - 2. Water to Water Water Source Heat Pumps
 - 3. Hydronic pumps
 - 4. Air Handlers
 - 5. Exhaust Fans
 - 6. Unit Heaters
 - 7. DX split systems
 - 8. Expansion tanks.
 - 9. Hydronic piping, valves, fittings, and specialties.
 - 10. Glycol feed pumps
 - 11. Ductwork and specialties.

12. Pipe and duct insulation.
13. VAV boxes
14. Equipment Supports
15. Automatic temperature controls.
16. Grilles, registers, louvers, and diffusers.
17. Vibration isolation.
18. Motor starters and disconnects.
19. Protection.
20. Identification.
21. Coordination.
22. Phasing.
23. Rigging.
24. Testing and Balancing Reports Air and Water.
25. Shop Drawings.
26. As-Built Drawings and Maintenance Manuals.
27. Warranties.
28. Commissioning

PART 2 PRODUCTS – NOT USED

PART 3 EXECUTION

3.1 GENERAL

- A. Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.
- B. Where corrosion can occur, appropriate corrosion resistant materials and assembly methods must be used including isolation of dissimilar metals against galvanic interaction. Resistance to corrosion must be achieved by the use of the appropriate base materials. Coatings shall be restored to only when specifically permitted by the Specification.
- C. Construct all equipment in accordance with requirements of all applicable codes. All pressure vessels and safety devices that fall within the scope of the ASME Code shall conform to the Code and bear the ASME label or stamp.
- D. Match and balance all system components to achieve compatibility of equipment or satisfactory operation and performance throughout the entire operating temperature and control ranges. All installations shall be in accordance with manufacturer's recommendations.
- E. Provide all controls, wiring, piping, valves, accessories and other components necessary to make all systems complete and operable.
- F. The contractor shall warranty all work, including labor and materials, and equipment furnished and installed as part of this contract for a minimum period of year from the

date of acceptance by the owner, in writing. Certain equipment, such as underground fuel tanks, may have longer warranties as indicated in the specifications. In such cases the longer of the two warranties shall prevail.

3.2 SHOP DRAWINGS AND SUBMITTALS (COORDINATE WITH DIVISION 1)

- A. Shop drawings and samples shall be prepared and submitted in accordance with the requirements established in the contract and shall consist of all items listed in the following paragraphs.
- B. Manufacturer's data or shop drawings giving full information as to dimensions, materials, and all information pertinent to the adequacy of the submitted equipment shall be submitted for review. Shop drawings shall include, but not be limited to the following:
- C. Submit all Mechanical equipment noted and scheduled on plans including but not limited to the following:
 - 1. Automatic Temperature Controls, Operation Sequences & Wiring Diagrams, and Control Diagrams hardware and software
 - 2. Motor Starters and Controllers
 - 3. Piping, valves, and specialties
 - 4. Expansion and Water Treatment Equipment Tanks
 - 5. Air handling units
 - 6. Geothermal well Field layout and piping, well materials
 - 7. Exhaust, return and spill fans.
 - 8. Water Source Heat Pump units
 - 9. Pumps and bases
 - 10. Vibration isolation
 - 11. Glycol data sheets
 - 12. Glycol feed pump and mixing tank
 - 13. Hangers and Inserts
 - 14. Equipment Supports and Vibration Eliminators
 - 15. Sheet Metal Construction Standards
 - 16. Piping Layout (1/4 scale)
 - 17. Ductwork Layout (1/4 scale)
 - 18. Insulation (piping and ductwork)
 - 19. Piping, Valves, fittings, and Specialties
 - 20. Filters
 - 21. Fan Curves and Sound Rating
 - 22. Coils
 - 23. Fire dampers, Motorized Dampers, Smoke dampers
 - 24. Diffusers Registers and Grilles
 - 25. Balancing Reports, Air and Water
 - 26. Coordinated Composite Drawings on Mylar with Piping, Ductwork, Conduits, Lights, registers Grilles and Smoke Detectors, etc.
- D. The contractor shall, upon award, submit a schedule for the engineer's review indicating when each of the above shop drawings shall be submitted. Submittals shall be made in a timely manner as the project progresses in accordance with the Construction manager or General contractor's work schedules. The contractor shall

allow sufficient time for the engineers to perform his review. A minimum of 10 business days shall be required. Untimely submittals shall be cause for the owner to make a delay against the contractor.

- E. Demolition, purchase and or installation shall not begin until shop drawings pertaining to the equipment associated with any related portion of the work have been submitted.
- F. Sheet metal shop drawings shall indicate all existing and/or new lights, walls, piping, structural elements, existing work, etc. and dimension locations of ductwork including elevations in relation to these items.
- G. Where shop drawings have been reviewed by the Engineer, such review shall not be considered as a guarantee of measurements or building conditions. Where drawings have been reviewed, said review does not mean that drawings have been checked in detail; said review does not substantiate any quantities and in any way relieve the Contractor from his responsibility nor the necessity of furnishing materials or performing work required by the Contract Drawings and Specifications. It does not relieve the contractor of the responsibility to perform all work to accepted industry standards and in a code compliant manner. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.
- H. Where substitutions are submitted for approval the review shall be for general performance comparison to the specified product. Products shall not be reviewed for size, clearance, or coordination with other trades. Coordination with other trades shall be the responsibility of the contractor. And changes to existing conditions or changes required to the work of other trades such because of substituted material or equipment approved or not shall be the responsibility of this contractor.
- I. Approval of shop drawings
 - 1. The Contractor shall be specifically responsible for checking equipment dimensions and clearances and confirming that equipment will fit into the designated space and connect properly to adjoining equipment and/or materials.
 - 2. Submittals marked "Make Corrections Noted" give authority to proceed in accordance with the notes. However, if drawings are also marked "Amend and Resubmit", corrected drawings must be resubmitted for final review.
 - 3. Submittals marked "Rejected" do not give authority to proceed with any portion of the work shown there-on. Drawings must be resubmitted.
 - 4. Submittals marked "Rejected" or "Amend and Resubmit" shall include a specific written response to the engineer's comments. Resubmission of a submittal without a written response to the engineer's comments will be considered incomplete and shall be returned un-reviewed.

3.3 CHARTS AND TAGS

- A. The Contractor shall provide three sets of charts and diagrams of all piping systems indicating the number and location of valves, controls, etc.
- B. All valves, dampers, and controls shall be designated with brass tags. Refer to section 23 05 23 Identification for HVAC Piping and equipment

3.4 GENERAL AND SUPPLEMENTARY CONDITIONS and Division 01 Specification Sections apply to this Section.

3.5 FEES & PERMITS

- A. The Contractor shall obtain all permits and pay all fees required related to this scope of work.

3.6 PAINTING

- A. All motors, fans and all other factory manufactured, and assembled apparatus shall be factory coated with one coat of primer and one coat of machinery enamel standard color at the factory and after installation, all finishes shall be cleaned and touched up to repair any damage incurred during construction.
- B. All piping shall be painted in colors conforming with OSHA Standards. All new and existing exposed iron and supplementary dunnage steel shall be finished according to specifications.
- C. All supports, nuts, bolts and hanger fasteners located outside shall be galvanized or nickel plated.

3.7 RIGGING

- A. Furnish all labor, materials and equipment required to rig equipment and materials.
- B. The rigger shall secure any necessary permits and comply with all applicable Federal, State, and local safety regulations. A copy of permits to be kept at both the project site and Engineer's Office.
- C. The rigger shall have a minimum of five (5) years of practical experience and hold a master riggers license if required.
- D. The procedure for rigging shall be submitted to the Engineer for review. All possible precautions should be taken to prevent damage to the structure, streets, sidewalks, curbs, lawns, etc.

3.8 CUTTING AND PATCHING

- A. All cutting and patching required for piping, ductwork, control conduits, etc., passing through walls, floors, and roof shall be provided by the Contractor under this contract unless otherwise noted. This Contractor shall be responsible for any damage done to the structure due to his negligence.
- B. Patching materials and application shall match existing construction.
- C. Where applicable, new holes for piping installation shall be core drilled.
- D. Pipe Sleeves & Fire-stopping:
 - 1. Provide for all pipes, conduits ducts, and other elements passing through floors, walls, partitions and structural elements, sleeves as specified. Sleeves shall be of adequate diameter to allow for a minimum of 3/4 inches clear all around sleeve and pipe. When pipe, conduit ducts or other such element penetrates other than fire rated assembly and is insulated, insulation shall pass continuously through sleeves with 1/2-inch clearance between insulation and sleeve.
 - 2. Where pipes, conduits and other such elements penetrate fire rated assemblies, or where holes or voids are created to extend mechanical systems through fire rated assemblies (walls, floors, ceilings, structure, etc.); sleeves and fire-stopping systems shall be installed.
- E. Furnish access doors, to the General Contractor for installation where required in finished walls, partitions and the like for access to junction boxes, controls, valves, etc, concealed behind finished construction.
- F. Submit location drawings and sizes for review prior to installation.

3.9 PROTECTION-COORDINATE WITH DIVISION 1

- A. Special protection is required for installation of a Derrick or other device for rigging purposes. This Contractor shall coordinate with the rigger to facilitate rigging work.
- B. Recommendations and Provisions of ANSI Bulletin A10.2 and OSHA shall be complied with in-so-far as applicable to the work.
- C. The Contractor shall provide temporary partitions or tarpaulins to protect adjacent spaces and/or equipment. He shall be responsible for any damage or injury to person or property of any character resulting from any act, omission, neglect or misconduct in his manner or method of executing his work.
- D. The Contractor shall restore at his own expense such property to a condition similar or equal to that existing before such damage or injury in an acceptable manner.
- E. The Contractor, furthermore, shall conduct his operations in such a manner as to prevent dust and debris from transferring on to adjoining property or into existing spaces.

- F. All openings cut in walls, floors, roof or ceilings of the building, for conduit, pipe, ductwork, etc., shall be closed off with box-type temporary protective enclosures of ¼" tempered hardboard, except when mechanics are actually working at the particular opening. Enclosures shall be constructed of fireproof 2x4 frame, four (4) sides covered and made completely dust and watertight.
- G. All finished floor areas through which the contractor must pass with materials or equipment shall be protected with a layer of ¼" hardboard, "Masonite", laid with joints taped together.

3.10 EQUIPMENT SUPPORTS

- A. A. Provide supplementary steel dunnage, curbs, angle iron stands, etc., to properly set and install all equipment, including supports necessary to properly pitch piping.

3.11 WELDING

- A. A. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.
- B. The handling and storage of all welding materials, acetylene and oxygen tanks, burners, and other equipment required for the execution of welding and cutting work shall be always subject to the approval of the Owner and/or Architect. All welding materials and gas tanks shall be promptly removed from the premises upon completion of each day's work or stored in a manner satisfactory to the owner. Welding and equipment shall conform to the American Welding Society's Code for Welding in Building Construction, latest edition as well as state and local laws and ordinances.
- C. Provide all temporary ventilation, and ventilation air systems required during welding operations as required by OSHA.

3.12 AS-BUILT DRAWINGS

- A. The Contractor shall provide a complete set of As-Built drawings showing actual installation and locations of all new and existing equipment, piping, and ductwork in the entire building. Schedules shall be revised to indicate actual equipment installed.
- B. As-Built drawings shall be submitted as per contract requirements in accordance with Division 1 and shall be submitted in paper format for review. Accepted as built shall then be submitted in AutoCAD format on hard disc.

3.13 CONDITIONS

- A. Inspection: Prior to all work of this Section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence. Verify that the work of this Section may be completed in

strict accordance with all pertinent codes and regulations, the approved Shop Drawings, and the Manufacturers' recommendations.

- B. Discrepancies: In the event of discrepancy, immediately notify the Engineer. Do not proceed in areas of discrepancy until all such discrepancies have been fully resolved.

3.14 INSTALLATION OF EQUIPMENT

- A. Locations: Install all equipment in the locations shown on the approved Shop Drawings except where specifically otherwise approved on the job by the Owner and/or Engineer.
- B. Interferences: Avoid interference with structure, and with work of other trades, preserving adequate headroom and clearing all doors and passageways to the approval of the Engineer.
- C. Inspection: Check each piece of equipment in the system for defects, verifying that all parts are properly furnished and installed, and that all items function properly, and that all adjustments have been made.

3.15 CLOSING-IN OF UNINSPECTED WORK

- A. General: Do not allow or cause any of the work to be covered up or enclosed until it has been inspected, tested, and accepted by the Engineer and by all other authorities having jurisdiction.
- B. Uncovering: Should any of the work of this Section be covered up or enclosed before it has been completely inspected, tested, and approved, do all things necessary to uncover all such work. After the work has been completely inspected, tested, and approved, provide all materials, and labor necessary and make all repairs necessary to restore the work to its original and proper condition at no additional cost to the owner.

3.16 BUILDING ACCESS

- A. The Contractor shall inform himself fully regarding peculiarities and limitations of space available for the passage and installation of all equipment and materials under the Contract.
- B. Verify and coordinate removal of existing construction and/or knock-down of equipment to suit conditions. Special attention should be given to equipment installation. Provide all labor and material to facilitate installation.

3.17 COOPERATION WITH OTHER TRADES PHASING

- A. Cooperate with other trades in order that all systems in the work may be installed in the best arrangements.

- B. Coordinate as required with all other trades to share space in common areas and to provide the maximum of access to each system.
- C. This Contractor shall submit fully coordinated shop drawings showing all piping, ductwork, and equipment, as well as relevant work of all other trades such as light, conduits, structural and steel, which may impact the final size or placement of piping, ductwork, equipment, diffusers and grilles.
- D. The work shall be scheduled and phased in accordance with the requirements of the contract and the client. Prior to the commencement of work the HVAC contractor shall submit a schedule in writing to the Architect and owner for approval. There shall be no shutdowns of any systems without prior written approval from the owner.

3.18 CLEANING

- A. It is the intent of the contract documents that all work, including the inside of equipment be left in a clean condition. All construction dirt shall be removed from material and equipment.
- B. All removed items shall be taken off the premises and discarded in a manner satisfactory to the Owner.

3.19 COMPLETENESS

- A. It is the intent of the contract documents to provide complete systems. Completeness shall mean not only that all material and equipment has been installed properly, but that all material and equipment is installed, adjusted, and operating as per the design intent in the opinion of the Engineer and in accordance with generally accepted industry good practice.
- B. Upon completion of all phases of work or before there is any danger from freezing the contractor fill the heating and cooling systems with a 35% glycol solution. Furnish 15 extra gallons in a steel drum for storage on site and future use by the owner.

3.20 FIRE PREVENTION DURING HOT WORK

- A. Before starting operations, the Contractor shall furnish trained personnel to provide fire watches for locations where hot work is to be performed. One fire watcher may observe several locations in a relatively small contiguous area. Contractor shall furnish suitable type, fully charged, operable portable fire extinguisher to each fire watcher.
- B. The Contractor shall provide fire watchers who know how to operate the fire extinguisher, how to turn on a fire alarm and how to summon the fire department.
- C. Before starting operations, take suitable precautions to minimize the hazard of a fire communicating to the opposite side of walls, floors, ceilings, and roofs from the operations.

3.21 SAFETY MEASURES

- A. Hot work shall not be done in or near rooms or areas where flammable liquids or explosive vapors are present or thought to be present. A combustible gas indicator (explosimeter) test shall be conducted to assure that each area is safe. The Contractor is responsible for arranging and paying for each test.
- B. Insofar as possible, the Contractor shall remove and keep the area free from all combustibles, including rubbish, paper and waste within a radius of 25 feet from hot operations.
- C. If combustible material cannot be removed, the Contractor shall furnish fireproof blankets to cover such materials. At the direction of the owner floors, walls, and ceilings of combustible material shall be wetted thoroughly with water before, during, and after operations sufficiently to afford adequate protection.
- D. Where possible, the Contractor shall furnish and use baffles of metal or gypsum board to prevent the spraying of sparks, hot slag and other hot particles into surrounding combustible material.
- E. The Contractor shall prevent the spread of sparks and particles of hot metal through open windows, doors, and holes and cracks in floors, walls, ceilings and roofs.
- F. Cylinders of gas used in hot work shall be placed a safe distance from the work. The Contractor shall provide hoses and equipment free of deterioration, malfunction and leaks. Suitable supports shall be provided to prevent accidental overturning of cylinders. All cylinder control valves shall be shut off while in use with the gas pressure regulator set at 15 psi or less.
- G. When hot work operations are completed or ended for the day, each location of the day's work shall be inspected by the Contractor 30 to 60 minutes after completion of operations to detect for hidden or smoldering fires and to ensure that proper housekeeping is maintained. Contractor shall cleanup the area of work at the end of each shift or workday.
- H. Where sprinkler protection exists, the sprinkler system shall be maintained without interruption while operations are being performed. If operations are performed close to automatic sprinkler heads, gypsum board sheets or damp cloth guards may be used to shield the individual heads temporarily. The heads shall be inspected by the Contractor immediately after hot work operations cease, to ensure all materials have been removed from the heads and that the heads have not been damaged.
- I. Suitable type, fully charged, operable portable fire extinguisher shall be available at all times during hot work operations.
- J. If any of the above safeguards are not employed, or are violated, the Contracting owners Representative may, by written notice, stop the work until compliance is obtained. Such stoppage shall not relieve the Contractor from performing his work within the Contract period for the Contract price.

3.22 USE OF OWNERS EQUIPMENT

- A. The contractor shall not use any the owner's HVAC system or equipment, new or existing, for any purpose. The contractor shall provide temporary HVAC equipment, ductwork, power, and controls for use during construction for the purpose of ventilation or heating during the construction process. All such equipment, ductwork, power, and controls shall be removed and the completion of work.

END OF SECTION

SECTION 23 05 13

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.
- B. Division 24 - Equipment Wiring Systems: Electrical characteristics and wiring connections.

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.

1.4 REFERENCES

- A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
- C. NEMA MG 1 - Motors and Generators.
- D. NFPA 70 - National Electrical Code.

1.5 REGULATORY REQUIREMENTS

- A. Conform to UL Component Recognition for appropriate sizes.
- B. Conform to NFPA 70 applicable electrical code, Underwriters Laboratories, Inc., and NEMA
- C. Conform to New York State energy code.

1.6 DELIVERY, STORAGE, AND PROTECTION

- A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.7 WARRANTY

- A. Provide five-year manufacturer warranty for all motors larger than ½ horsepower.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Gould.
 - 2. Century.
 - 3. General Electric.
 - 4. Square D

2.2 GENERAL MOTOR REQUIREMENTS

- A. Comply with NEMA MG 1 unless otherwise indicated.
- B. Comply with IEEE 841 for severe-duty motors.
- C. All electric motors of sizes and types as specified for driving mechanical equipment shall be provided under this section.
- D. Electrical Service: All motors shall be 60 Hertz unless otherwise noted. Refer to Electrical Specifications for required electrical characteristics.
- E. Motors: Design for continuous operation in 40° C environment, and for temperature rise in accordance with ANSI/NEMA MG limits for insulation class, Service Factor, and motor enclosure type. Motors shall be of sufficient size for duty to be performed.

- F. Visible Nameplate: Indicating manufacturer's name and model number, motor horsepower, RPM, frame size, voltage, phase, cycles, full load amps, insulation system class, service factor, maximum ambient temperature, temperature rise at rated horsepower, minimum efficiency, power factor.
- G. Electrical Connection: Conduit connection boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide screwed conduit connection in end frame. Size motor boxes to receive motor feeders and ground cable indicated on electrical drawing schedules.
- H. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.
- I. 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 MOTOR EFFICIENCY

- A. Electric motors shall meet the minimum efficiency requirement of the following tables in accordance with International Energy conservation code when tested in accordance with DOE CFR 431. Performance data shall be certified by approved testing agency.
- B. Subtype I motors – NEMA premium efficiency as per table NEMA MG 1 table 12-12 and International Energy Conservation code table 405.8(1). This shall apply to general purpose, T-frame, single speed, squirrel cage, induction type; 230/460-V, NEMA Designs A or B, continuous rated, 60 Hz, from 1 to 200 hp, 2-, 4- and 6-pole (3600-, 1800- and 1200-rpm), open and enclosed. Subtype I motors 250 hp to 500 hp motor efficiency shall be able NEMA MG 1 table 12-11 and International Energy Conservation Code table 405.8(1).
- C. Subtype II motors – NEMA efficiency as per table NEMA MG 1 table 12-11 and International Energy Conservation code table 405.8(2). This shall apply to general purpose motors but can configured as U-frame motors; NEMA Design C motors; close-coupled pump motors; footless motors; vertical solid shaft normal thrust motors (as tested in a horizontal position); eight-pole (900 rpm) motors, and polyphase motors with a voltage of not more than 600 V (other than 230 or 460 V).
- D. Minimum average full load efficiency of polyphase small electric motors up to 3 hp shall be in accordance with Table C405.8(3) of the International Energy Conservation Code
- E. Minimum average full load efficiency for capacitor-start, capacitor-run and capacitor-start induction-run small electric motors up to 3 hp shall be in accordance with Table C405.8(4) of the International Energy Conservation Code.

2.4 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Service Factor: 1.15.

- C. 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.
- D. Multispeed Motors: Separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Re-greaseable, shielded, antifriction ball bearings suitable for radial and thrust loading. Grease lubricated anti-friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L-10 life of 200,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- G. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay with wiring to terminal box.
- H. Sound Power Levels: To NEMA MG 1.
- I. Temperature Rise: Match insulation rating.
- J. Insulation: Class B or better.
- K. 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.
- L. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.5 ADDITIONAL REQUIREMENTS FOR POLYPHASE MOTORS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Use part winding Start above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- C. Motors Used with Variable-Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width-modulated inverters.
 - 2. Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

- D. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.6 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.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, pre-lubricated sleeve ball bearings.

2.7 POWER FACTOR CORRECTION

- A. Provide a capacitor for each three phase, single speed motor rated 3 HP or larger shall be provided to correct the full load power factor to 95%. The capacitor shall be mounted at the motor for connection across the motor terminals by Electrical Contractor.
- B. Capacitors;
 - 1. Capacitors shall be totally enclosed, fused and with discharge resistors.
 - 2. Capacitors based on nominal motor RPM shall be provided in accordance with the following table to correct power factor to 95% and verify sizes with motor manufacturer.

Motor HP	Capacitor KVAR 3600 RPM Motor	Capacitor KVAR 1800 RPM Motor
3	1.5	1.5
5	2	2
7.5	2.5	2.5
10	3	3
15	4	4
20	5	5
25	6	6
30	7	7
40	9	9
50	12	12
60	14	14

2.8 STARTERS

A. GENERAL

1. See specification Section 16485 and Division 1 for additional information.
2. Starters for motors operating at 120 volts shall be manual starters unless otherwise indicated. Starters for motors operating at other than 120 volts shall be magnetic starters.
3. All starters shall be enclosed. Enclosures shall be surface mounted NEMA 1 unless otherwise indicated.
4. Where weatherproof starters are required, the enclosure shall be NEMA 4.
5. It shall be verified that the correct overload heaters have been installed in the starter before energizing any motor. Sizing shall be based on motor nameplate current and considering any reduction in current due to power factor correction.
6. Alternate Manufacturers –
 - a. Allen-Bradley
 - b. Crouse-Hinds Co.
 - c. Cutler-Hammer, Inc.
 - d. General Electric Co.
 - e. Square D Co.
 - f. Westinghouse Electric Corp.

B. MANUAL STARTERS

1. Two-pole, toggle operated, thermal overload device in each phase leg, handle guard for padlocking toggle handle and with indicated control and signal devices.
2. Where a motor is controlled automatically by an interlock or pilot device, a "HAND-OFF-AUTO" switch shall be provided in the starter cover. Where the rating of the interlock or pilot device is inadequate to control the motor currents directly, a properly rated contactor shall be provided between the controlling device and the motor.
3. An "ON" pilot light shall be provided in the starter cover.

C. MAGNETIC STARTERS

1. Starters shall be sized in accordance with NEMA standards and the following table except that starters shall not be smaller than NEMA size 0. Starters shall be provided with one N.O. electrical holding interlock, under voltage protection and two additional auxiliary contacts within the same enclosure. NEMA size starters shall be provided as follows

STARTER SIZE	MAX HP AT 460 VOLTS
0	5
1	10
2	25

2. All starters shall be combination type with the starter and disconnect in the same enclosure. All starters shall be Type 2 coordination protected. Fuses shall be Bussman "Low Peak" type or equal sized at 125% of motor nameplate rating. Verify and coordinate requirements for fused disconnect switches with the Electrical Contractor prior to ordering starters.
3. Provide S.S.P.B. or H-O-A switches and pilot light in covers as required to facilitate control operation sequences.

D. CRITICAL FAULT

1. Where starters are not integral to equipment and are furnished and installed separately from equipment by the contractor, provide a 3-phase line voltage monitor by ICM Controls model 450 or approved equal. Unit shall be installed in the motor starter or in a separate enclosure with the same rating as the starter. It shall be arranged to monitor critical faults including phase loss or reversal, and when detected, de-energize the load. It shall monitor non-critical faults including high/low voltage, voltage unbalance and when detected, after a time delay de-energize the load.

PART 3 EXECUTION

- A. Suitable starting and controlling equipment and devices shall be furnished and installed as specified hereinafter and as shown on the Drawings. The starting equipment shall be arranged, generally, in control groups, or in certain cases, as isolated combination starters as specified or indicated. The Heating Ventilating and Air Conditioning Sequences of Operation, drawings and specifications shall be referred to for the manner of control, operation and monitoring of motors and the electrically operated equipment.
- B. A starter and disconnect switch or combination motor starter disconnect shall be provided for every motor and each electrically operated piece of equipment by this contractor except where complete starters and controls are furnished by the manufacturer of the motor or piece of equipment. Starters shall be internally wired to provide the required control operation and monitoring. All control devices such as push buttons, break-glass stations, alternators, relays, pilot lights, etc., shall be provided as required for operation of mechanical equipment. All roof top and remotely located

equipment shall have remote starters as located on plan and shall have local disconnect switches. All equipment located in equipment rooms can use combination starters/disconnects located within line of site of controlled equipment. All starters and disconnect switches shall be in enclosures suitable for the environment in which they are installed. Starters and disconnect switches located in machine rooms shall use NEMA 1. Starters and disconnect switches located outdoors shall use NEMA 4x. Starters and disconnect switches located in machine rooms which are subject to potential water damage shall use NEMA 2.

- C. Starting equipment and devices specified in this section (and section 23 29 13 Variable Frequency Controllers), shall be furnished by the mechanical subcontractor, and shall be installed by the Electrical subcontractor. In general, the mechanical subcontractor shall furnish all motor starters and disconnect switches except where they are an integral part of a motor control center, in this case starters and disconnects shall be provided, (furnished and installed), by the electrical contractor. The Electrical subcontractor shall also provide all wiring necessary to supply power to the electric motors specified under this section, including connections from the starters to the motors. Starters and disconnects shall also include variable frequency drives.
- D. The mechanical Contractor shall furnish and install all wiring between control devices and controlled equipment furnished under this Section, including interlock control wiring between motor starters, and all automatic temperature control wiring. All wiring shall be installed in conformance with applicable codes and the requirements of the Electrical Division of the Specifications.
- E. The Electrical Contractor shall furnish a 120-volt power source to temperature control panels and equipment requiring a separate 120-volt control power source. Power for control circuits for all devices connecting to motor starters shall be obtained from 120-volt control transformers provided in each starter operating at other than 120 volts. Provide transformers for all low voltage control systems as required.
- F. Furnish detailed composite wiring diagrams and such other information necessary to assure the proper connection, operation, and control of motorized equipment, including interlocks, automatic controls, safety controls and all auxiliary circuits.
- G. All control units shall be furnished with a nameplate indicating which device or equipment it controls, the voltage. Additional nameplates on each push button, selector switch and pilot light indicating their functions shall be provided. Nameplates shall be laminated phenolic with white letters on black background, minimum 2" high.
- H. All motors supplied either with equipment or installed separately that are to be used in conjunction with variable frequency drive shall be inverter duty motors.

END OF SECTION

SECTION 23 05 16

EXPANSION FITTINGS AND LOOPS 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. Flexible hose packless expansion joints.
 - 2. Pipe loops and swing connections.
 - 3. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
- B. Capability: Products to absorb 200 percent of maximum axial movement between anchors.
- C. Expansion Calculations:
 - 1. Installation temperature: 40deg F.
 - 2. Dual Temperature water heating: 220 deg F.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.

4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
- C. Welding certificates.
- D. Product Certificates: For each type of expansion joint, from manufacturer.
- E. Maintenance Data: For expansion joints to include in maintenance manuals.

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."
 2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 PACKLESS EXPANSION JOINTS

- A. Flexible-Hose Packless Expansion 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. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Metraflex, Inc.
 2. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
 3. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
 4. Expansion Joints for Copper Tubing NPS 2 and Smaller: Copper-alloy fittings with solder-joint end connections.
 - a. Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
 - b. Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F and 500 psig at 450 deg F ratings.
 5. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4: Copper-alloy fittings with flanged end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 420 psig at 70 deg F and 315 psig at 450 deg F ratings.
 6. Expansion Joints for Steel Piping NPS 2 and Smaller: Carbon-steel fittings with threaded end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 700 psig at 70 deg F and 515 psig at 600 deg F ratings.

7. Expansion Joints for Steel Piping NPS 2-1/2 to NPS 6: Carbon-steel fittings with flanged end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 275 psig at 70 deg F and 200 psig at 600 deg F ratings.
8. Expansion Joints for Steel Piping NPS 8 to NPS 12: Carbon-steel fittings with weld end connections.
 - a. Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.
 - b. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.
9. Expansion Joints for Steel Piping NPS 14 and Larger: Carbon-steel fittings with weld end connections.
 - a. Stainless-steel hoses and double-braid, stainless-steel sheaths with 165 psig at 70 deg F and 120 psig at 600 deg F ratings.

2.2 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

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. Flex-Hose Co., Inc.
 - b. Flexicraft Industries.
 - c. Metraflex, Inc.
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.

B. Anchor Materials:

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.
5. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened Portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install two guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
- C. Attach guides to pipe and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 23 05 17

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 SUSTAINABLE DESIGN OBJECTIVES

- A. The City requires the contractor to implement practices and procedures to meet the project's environmental performance goals, which include:
 - 1. Minimize the environmental impacts of the construction and operation of the project during the construction phase. The project shall implement the following procedures singly or in combination:
 - a. Select products that minimize consumption of non-renewable resources, consume reduced amounts of energy, minimize environmental pollution, and to utilize recycled and/or recyclable materials.
 - b. Reduce sources of potential Indoor Air Quality pollutants by controlled selection of materials and processes used in project construction. (015721)
 - c. Minimize waste produced by construction through efficient construction practices and landfill diversion, as detailed in the Construction Waste Management Plan. (017419)
 - 2. Products and processes that achieve the above objectives have been selected and included in the Construction Documents.

1.3 SUMMARY

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

1.4 ACTION SUBMITTALS

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

1.5 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements of the Construction Indoor Air Quality Management Plan and the Construction Waste Management Plan.

1.6 PROJECT CONDITIONS

- A. Waste Management: Comply with the requirements of the Construction Waste Management Plan.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.
- B. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

2.2 GROUT

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

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

- B. Install sleeves in concrete floors, concrete roof slabs, and concrete walls.
 - 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.
- C. Install sleeves for pipes passing through interior partitions.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants".
- D. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 SLEEVE AND SLEEVE-SEAL SCHEDULE

- A. Use sleeves and sleeve seals for the following piping-penetration applications:
 - 1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6: Cast-iron wall sleeves.
 - b. Piping NPS 6 and Larger: Cast-iron wall sleeves.
 - 2. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel-pipe sleeves.
 - 3. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
 - b. Piping NPS 6 and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION

SECTION 23 05 18

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 SUSTAINABLE DESIGN OBJECTIVES

- A. The City requires the contractor to implement practices and procedures to meet the project's environmental performance goals, which include:

- 1. Minimize the environmental impacts of the construction and operation of the project during the construction phase. The project shall implement the following procedures singly or in combination:
 - a. Select products that minimize consumption of non-renewable resources, consume reduced amounts of energy, minimize environmental pollution, and to utilize recycled and/or recyclable materials.
 - b. Reduce sources of potential Indoor Air Quality pollutants by controlled selection of materials and processes used in project construction. (015721)
 - c. Minimize waste produced by construction through efficient construction practices and landfill diversion, as detailed in the Construction Waste Management Plan. (017419)

- 1.3 Products and processes that achieve the above objectives have been selected and included in the Construction Documents.

1.4 SUMMARY

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

1.5 ACTION SUBMITTALS

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

1.6 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements of the Construction Indoor Air Quality Management Plan and the Construction Waste Management Plan.

1.7 PROJECT CONDITIONS

- A. Waste Management: Comply with the requirements of the Construction Waste Management Plan.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS FOR SUSTAINABLE DESIGN- GENERAL

- A. All field applied paints, coatings, sealants, sealer, adhesives in this section shall meet the requirements of VOC limits in 016116- Indoor Finishes Performance Requirements.
- B. All Products in this Section shall be free of Materials of Concern as noted in 015721- Indoor Air Quality Control (where achievable).

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 chrome-plated finish and spring-clip fasteners.
- C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.
- D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.
- E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.3 FLOOR PLATES

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

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install escutcheons for piping penetrations of walls, ceilings, and finished floors.
- B. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. Escutcheons for New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome-Plated Piping: One-piece, cast-brass type with polished, chrome-plated finish.
 - c. Insulated Piping: One-piece, stamped-steel type.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished, chrome-plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type with polished, chrome-plated finish.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type.
 - 2. Escutcheons for Existing Piping:
 - a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
 - b. Insulated Piping: Split-plate, stamped-steel type with concealed hinge.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge.
 - g. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
 - h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed hinge.
 - i. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.

- j. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with concealed hinge.
- C. Install floor plates for piping penetrations of equipment-room floors.
- D. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.
 - 1. New Piping: One-piece, floor-plate type.
 - 2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION

SECTION 23 05 19

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. Bimetallic-actuated thermometers.
2. Filled-system thermometers.
3. Liquid-in-glass thermometers.
4. Light-activated thermometers.
5. Thermowells.
6. Dial-type pressure gages.
7. Gage attachments.
8. Test plugs.
9. Test-plug kits.
10. Sight flow indicators.
11. Orifice flow Meters

B. Related Sections:

1. Section 221123 "Facility Natural-Gas Piping" for gas meters.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

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

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

1. Terrice, H. O. Co.
2. Watts; a Watts Water Technologies company.
3. Weiss Instruments, Inc.
4. Weksler Glass Thermometer Corp.

2.2 BIMETALLIC-ACTUATED THERMOMETERS

- A. Standard: ASME B40.200.
- B. Case: Liquid-filled and sealed type(s); stainless steel with 5-inch nominal diameter.
- C. Dial: Nonreflective aluminum with permanently etched scale markings and scales in deg F and deg C.
- D. Connector Type(s): Union joint, adjustable angle, with unified-inch screw threads.
- E. Connector Size: 1/2 inch, with ASME B1.1 screw thread.
- F. Stem: 0.25 or 0.375 inch in diameter; stainless steel.
- G. Window: Plain glass.
- H. Ring: Stainless steel.
- I. Element: Bimetal coil.
- J. Pointer: Dark-colored metal.
- K. Accuracy: Plus, or minus 1 percent of scale range.

2.3 FILLED-SYSTEM THERMOMETERS

- A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
 1. Standard: ASME B40.200.
 2. Case: Sealed type, cast aluminum or drawn steel; 5-inch nominal diameter.
 3. Element: Bourdon tube or other type of pressure element.
 4. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.

5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Pointer: Dark-colored metal.
7. Window: Glass.
8. Ring: Stainless steel.
9. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus, or minus 1 percent of scale range.

B. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Standard: ASME B40.200.
2. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back or front flange and holes for panel mounting.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Pointer: Dark-colored metal.
7. Window: Glass.
8. Ring: Stainless steel.
9. Connector Type(s): Union joint, back or bottom; with ASME B1.1 screw threads.
10. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.

11. Accuracy: Plus, or minus 1 percent of scale range.

2.4 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:

1. Standard: ASME B40.200.
2. Case: Cast aluminum; 6-inch nominal size.
3. Case Form: Back angle unless otherwise indicated.
4. Tube: Glass with magnifying lens and blue or red organic liquid.
5. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
6. Window: Glass or plastic.
7. Stem: Aluminum or brass and of length to suit installation.
 - a. Design for Air-Duct Installation: With ventilated shroud.
 - b. Design for Thermowell Installation: Bare stem.

8. Connector: 3/4 inch, with ASME B1.1 screw threads.
9. Accuracy: Plus, or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:

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

2.5 DUCT-THERMOMETER MOUNTING BRACKETS

- A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.6 THERMOWELLS

A. Thermowells:

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

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

2.7 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- Terice, H. O. Co.
 - Watts; a Watts Water Technologies company.
 - Weiss Instruments, Inc.
 - Weksler Glass Thermometer Corp.
- B. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
- Standard: ASME B40.100.
 - Case: Liquid-filled Sealed Solid-front, pressure relief type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
 - Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - Movement: Mechanical, with link to pressure element and connection to pointer.
 - Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
 - Pointer: Dark-colored metal.
 - Window: Glass.
 - Ring: Metal.
 - Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.
- C. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:
- Standard: ASME B40.100.
 - Case: Liquid-filled Sealed type; cast aluminum or drawn steel; 4-1/2-inch nominal diameter with back flange and holes for panel mounting.
 - Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
 - Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
 - Movement: Mechanical, with link to pressure element and connection to pointer.
 - Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
 - Pointer: Dark-colored metal.
 - Window: Glass.
 - Ring: Metal.
 - Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.8 GAGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass or stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

- C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.9 TEST PLUGS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Terice, H. O. Co.
 - 2. Watts; a Watts Water Technologies company.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Glass Thermometer Corp.
- 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: EPDM self-sealing rubber.

2.10 TEST-PLUG KITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Sisco Manufacturing Company, Inc.
 - 2. Terice, H. O. Co.
 - 3. Watts; a Watts Water Technologies company.
 - 4. Weiss Instruments, Inc.
- B. Furnish one test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.
- C. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.
- D. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.
- E. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.
- F. Carrying Case: Metal or plastic, with formed instrument padding.

2.11 FLOWMETERS

A. Turbine Flowmeters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advantage Controls.
 - b. EMCO Flow Systems.
 - c. ERDCO Engineering Corp.
 - d. Hoffer Flow Controls, Inc.
 - e. ONICON Incorporated.
2. Description: Flowmeter with sensor and indicator. Construction shall meet all sections of AWWA standard C-708.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Impeller turbine; for inserting into pipefitting or for installing in piping and measuring flow directly in gallons per minute.
 - a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for water.
 - b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
 - c. Minimum Pressure Rating: 150 psig.
 - d. Minimum Temperature Rating: 40 deg F.
5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus, or minus 1-1/2 percent.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Operating Instructions: Include complete instructions with each flowmeter.

2.12 THERMAL-ENERGY METERS

A. Impeller-Turbine, Thermal-Energy Meters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Hoffer Flow Controls, Inc.
 - b. ISTECH Corporation.
 - c. ONICON Incorporated.
2. Description: System with strainer, flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Impeller turbine with corrosion-resistant-metal body and transmitter; for installing in piping.

- a. Design: Total thermal-energy measurement.
 - b. Minimum Pressure Rating: [150 psig].
 - c. Minimum Temperature Range: [40 to 250 deg F].
4. Temperature Sensors: Insertion-type transducer.
5. Indicator: Solid-state, integrating-type meter; for wall mounting.
 - a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
 - b. Battery Pack: Five-year lithium battery.
6. Accuracy: Plus or minus 1 percent.
7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
8. Strainer: Full size of main line piping.
9. Operating Instructions: Include complete instructions with each thermal-energy meter system.

B. Ultrasonic, Thermal-Energy Meters:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. EMCO Flow Systems.
 - b. ONICON Incorporated.
 - c. SIEMENS Industry, Inc.; Energy Management Division.
 - d. Veris Industries.
2. Description: Meter with flow sensor, temperature sensors, transmitter, indicator, and connecting wiring.
3. Flow Sensor: Transit-time ultrasonic type with transmitter.
4. Temperature Sensors: Insertion-type or strap-on transducer.
5. Indicator: Solid-state, integrating-type meter.
 - a. Data Output: Six-digit electromechanical counter with readout in kilowatts per hour or British thermal units.
 - b. Battery Pack: Five-year lithium battery.
6. Accuracy: Plus or minus 1 percent.
7. Display: Visually indicates total fluid volume in gallons and thermal-energy flow in kilowatts per hour or British thermal units.
8. Operating Instructions: Include complete instructions with each thermal-energy meter system.

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 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.
 - 4. Two inlets and two outlets of each hydronic heat exchanger.
 - 5. Air side - Outside-, return-, supply-, and mixed-air ducts.
- V. Install pressure gages in the following locations:
 - 1. Inlet and discharge of each pressure-reducing valve station
 - 2. Inlet and outlet of strainers.
 - 3. Inlet and outlet of coils
 - 4. Suction and discharge side of each 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.
- 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 shall be one of the following:
 - 1. Sealed, bimetallic-actuated type.
 - 2. Direct or Remote-mounted, metal-case, vapor-actuated type.
 - 3. Compact or Industrial-style, liquid-in-glass type.
 - 4. Test plug with EPDM self-sealing rubber inserts.
 - 5. Industrial-style, liquid-in-glass type.
- B. Industrial type, liquid in glass type thermometers shall be installed at all the inlets and outlets of each of the following equipment:

1. Hydronic pump
 2. Hydronic Heat exchanger boiler
 3. Air handling units
 4. Provide test with EPDM self-sealing rubber inserts.
- C. Thermometers at inlet and outlet of each hydronic coil in air-handling units or duct mounted and built-up central systems shall be one of the following:
1. Liquid-filled or Sealed, bimetallic-actuated type.
 2. Direct or Remote-mounted, metal-case, vapor-actuated type.
 3. Compact or Industrial-style, liquid-in-glass type.
 4. Test plug with EPDM self-sealing rubber inserts.
- D. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:
1. Liquid-filled or Sealed, bimetallic-actuated type.
 2. Direct or Remote-mounted, metal-case, vapor-actuated type.
 3. Compact or Industrial-style, liquid-in-glass type.
 4. Test plug with EPDM self-sealing rubber inserts.
- E. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
1. Liquid-filled or Sealed, bimetallic-actuated type.
 2. Direct or Remote-mounted, metal-case, vapor-actuated type.
 3. Compact or Industrial-style, liquid-in-glass type.
- F. Thermometer stems shall be of length to match thermowell insertion length.
- 3.5 THERMOMETER SCALE-RANGE SCHEDULE
- A. Scale Range for Heating, Hot-Water Piping: 0 to 250 deg F.
 - B. Scale Range for Air Ducts: 0 to 150 deg F.
- 3.6 PRESSURE-GAGE SCHEDULE
- A. Pressure gages at all the inlet and discharge connections of each of the following equipment shall be liquid filled and sealed direct mounting, metal case.
 1. Pressure-reducing valve
 2. Hydronic pump
 3. Hydronic boiler
 4. Air handling and duct mounted units' coils
 5. Provide test with EPDM self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

- A. Scale Range for Heating, Hot-Water Piping: 0 to 160 psi.

END OF SECTION

SECTION 23 05 23
VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Bronze angle valves.
 - 2. Globe valves.
 - 3. Ball Valves
 - 4. Butterfly Valves.
 - 5. Check Valves
 - 6. Gate Valves
 - 7. Chainwheels.

1.3 DEFINITIONS

- A. CWP: Cold 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 angle and globe valves closed to prevent rattling.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.

2. Store valves indoors and maintain at higher-than-ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. 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. Refer to HVAC valve schedule articles for applications of valves.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream piping unless otherwise indicated.
- F. Valves in Insulated Piping:
 1. Include 2-inch stem extensions. Extensions must be provided and coordinated to allow for full proper insulation of piping, valves and all components.
 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.
- G. 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.
- H. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Apollo Valves; Conbraco Industries, Inc.
- b. Crane; Crane Energy Flow Solutions.
- c. Milwaukee Valve Company.
- d. NIBCO INC.
- e. Stockham; Crane Energy Flow Solutions.
- f. Watts; a Watts Water Technologies company.
- g. Keystone

GLOBE VALVES

2.2 BRONZE GLOBE VALVES

A. Class 150 Bronze Globe Valves:

1. Description:

- a. Standard: MSS SP-80, Type 2.
- b. CWP Rating: 300 psig.
- c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
- d. Ends: Threaded.
- e. Stem: Bronze.
- f. Disc: Bronze or PTFE.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron, bronze, or aluminum.

2.3 IRON GLOBE VALVES

A. Class 125 Iron Globe Valves:

1. Description:

- a. Standard: MSS SP-85, Type I.
- b. CWP Rating: 200 psig.
- c. Body Material: ASTM A 126, gray iron with bolted bonnet.
- d. Ends: Flanged.
- e. Trim: Bronze.
- f. Packing and Gasket: Asbestos free.
- g. Operator: Handwheel or chainwheel.

B. Class 250 Iron Globe Valves:

1. Description:

- a. Standard: MSS SP-85, Type I.
- b. CWP Rating: 500 psig.
- c. Body Material: ASTM A 126, gray iron with bolted bonnet.
- d. Ends: Flanged.
- e. Trim: Bronze.
- f. Packing and Gasket: Asbestos free.

- g. Operator: Handwheel or chainwheel.

BALL VALVES

2.4 BRASS BALL VALVES

A. Two-Piece Brass Ball Valves with Full Port and Brass Trim:

1. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Forged brass.
- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Brass.
- i. Ball: Chrome-plated brass.
- j. Port: Full.

B. Two-Piece Brass Ball Valves with Full Port and Stainless-Steel Trim:

1. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Forged brass.
- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Stainless steel.
- i. Ball: Stainless steel, vented.
- j. Port: Full.

C. Two-Piece Brass Ball Valves with Regular Port and Brass Trim:

1. Description:

- a. Standard: MSS SP-110.
- b. SWP Rating: 150 psig.
- c. CWP Rating: 600 psig.
- d. Body Design: Two piece.
- e. Body Material: Forged brass.
- f. Ends: Threaded.
- g. Seats: PTFE.
- h. Stem: Brass.
- i. Ball: Chrome-plated brass.
- j. Port: Regular.

D. Two-Piece Brass Ball Valves with Regular Port and Stainless-Steel Trim:

1. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Brass or bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Regular.

2.5 BRONZE BALL VALVES

A. Two-Piece Bronze Ball Valves with Full Port and Bronze or Brass Trim:

1. 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.

B. Two-Piece Bronze Ball Valves with Full Port and Stainless-Steel Trim:

1. 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: Stainless steel.
 - i. Ball: Stainless steel, vented.
 - j. Port: Full.

C. Two-Piece Bronze Ball Valves with Regular Port and Bronze or Brass Trim:

1. 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: Regular.

2.6 IRON BALL VALVES

A. Class 125 Iron Ball Valves:

- 1. Description:
 - a. Standard: MSS SP-72.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Split body.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Ends: Flanged.
 - f. Seats: PTFE.
 - g. Stem: Stainless steel.
 - h. Ball: Stainless steel.
 - i. Port: Full.

BUTTERFLY VALVES

2.7 DUCTILE-IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:

- 1. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. CWP Rating: 175 psig.
 - c. Body Material: Coated, ductile iron.
 - d. Stem: Two-piece stainless steel.
 - e. Disc: Coated, ductile iron.
 - f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:

- 1. Description:
 - a. Standard: MSS SP-67, Type I.
 - b. NPS 8 and Smaller CWP Rating: 300 psig.
 - c. NPS 10 and Larger CWP Rating: 200 psig.
 - d. Body Material: Coated, ductile iron.
 - e. Stem: Two-piece stainless steel.
 - f. Disc: Coated, ductile iron.
 - g. Seal: EPDM.

CHECK VALVES

2.8 BRONZE LIFT CHECK VALVES

- A. Class 125 Lift Check Valves with Bronze Disc:
 - 1. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.
- B. Class 125 Lift Check Valves with Nonmetallic Disc:
 - 1. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: NBR or PTFE.

2.9 BRONZE SWING CHECK VALVES

- A. Class 125, Bronze Swing Check Valves with Bronze Disc:
 - 1. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.
- B. Class 125, Bronze Swing Check Valves with Nonmetallic Disc:
 - 1. Description:
 - a. Standard: MSS SP-80, Type 4.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: PTFE.
- C. Class 150, Bronze Swing Check Valves with Bronze Disc:
 - 1. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 300 psig.
 - c. Body Design: Horizontal flow.

- d. Body Material: ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: Bronze.

D. Class 150, Bronze Swing Check Valves with Nonmetallic Disc:

1. Description:

- a. Standard: MSS SP-80, Type 4.
- b. CWP Rating: 300 psig.
- c. Body Design: Horizontal flow.
- d. Body Material: ASTM B 62, bronze.
- e. Ends: Threaded.
- f. Disc: PTFE.

2.10 IRON SWING CHECK VALVES

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

1. 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 A 126, gray iron with bolted bonnet.
- f. Ends: Flanged.
- g. Trim: Bronze.
- h. Gasket: Asbestos free.

B. Class 125, Iron Swing Check Valves with Nonmetallic-to-Metal Seats:

1. 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 A 126, gray iron with bolted bonnet.
- f. Ends: Flanged.
- g. Trim: Composition.
- h. Seat Ring: Bronze.
- i. Disc Holder: Bronze.
- j. Disc: PTFE.
- k. Gasket: Asbestos free.

C. Class 250, Iron Swing Check Valves with Metal Seats:

1. Description:

- a. Standard: MSS SP-71, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
- c. NPS 14 to NPS 24, CWP Rating: 300 psig.
- d. Body Design: Clear or full waterway.

- e. Body Material: ASTM A 126, gray iron with bolted bonnet.
- f. Ends: Flanged.
- g. Trim: Bronze.
- h. Gasket: Asbestos free.

2.11 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

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

- 1. 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 A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.
 - i. Closure Control: Factory-installed, exterior lever and spring.

2.12 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

- 1. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Material: ASTM A 126, gray iron.
 - e. Style: Compact wafer.
 - f. Seat: EPDM.

B. Class 150, Iron, Compact-Wafer, Center-Guided Check Valves with Resilient Seat:

- 1. Description:
 - a. Standard: MSS SP-125.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 250 psig.
 - d. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - e. Style: Compact wafer.
 - f. Seat: EPDM.

2.13 IRON, PLATE-TYPE CHECK VALVES

A. Class 125, Iron, Single or dual Plate Check Valves with Resilient Seat:

- 1. Description:
 - a. Standard: API 594.

- 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: Wafer, spring-loaded plate.
 - e. Body Material: ASTM A 126, gray iron.
 - f. Seat: EPDM.
- B. Class 150, Iron, single or Dual-Plate Check Valves with Resilient Seat:
 - 1. Description:
 - a. Standard: API 594.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 250 psig.
 - d. Body Design: Wafer, spring-loaded plates.
 - e. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
 - f. Seat: EPDM.

GATE VALVES

- A. Class 150, RS, Bronze Gate Valves:
 - 1. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.
- B. Class 125, OS&Y, Iron Gate Valves:
 - 1. Description:
 - a. Standard: MSS SP-70, 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 Material: ASTM A 126, gray iron with bolted bonnet.
 - e. Ends: Flanged.
 - f. Trim: Bronze.
 - g. Disc: Solid wedge.
 - h. Packing and Gasket: Asbestos free.
- C. Class 250, OS&Y, Iron Gate Valves:
 - 1. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 500 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 300 psig.
 - d. Body Material: ASTM A 126, gray iron with bolted bonnet.

- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.

2.14 CHAINWHEELS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Babbitt Steam Specialty Co.
 - 2. Roto Hammer Industries.
 - 3. Trumbull Industries.
- B. Description: Valve actuation assembly with sprocket rim, chain guides, chain, and attachment brackets for mounting chainwheels directly to handwheels.
 - 1. Sprocket Rim with Chain Guides: Ductile or cast iron Aluminum, 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 threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.

- D. Install valves in position to allow full stem movement.
- E. Install chainwheels on operators for valves NPS 6 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.
- G. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
 - 3. Lift Check Valves: With stem upright and plumb.

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. Throttling Service except Steam: Globe valves.
- B. If valves with specified CWP ratings are unavailable, the same types of valves with higher CWP ratings may be substituted.
- C. Select valves 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.

3.5 VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller: Bronze, check, ball or globe valves, Class 150, bronze nonmetallic disc, with soldered or threaded ends.
- B. Pipe NPS 2-1/2 and Larger: check, globe valves, or gate Class 250 iron body with flanged ends.

END OF SECTION

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

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

- B. Related Sections:

- 1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Hangers and supports for HVAC 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.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Sustainable Design Submittals:
 1. Environmental Product Declaration: For each product.
 2. Health Product Declaration: For each product.
 3. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. Shop Drawings: Show fabrication and installation details and include calculations for the following: include Product Data for components:
 1. Trapeze pipe hangers.
 2. Metal framing systems.
 3. Pipe stands.
 4. Equipment supports.
- D. 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. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.7 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

2. Galvanized Metallic Coatings: Pre-galvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

B. 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.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-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. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. B-line, an Eaton business.
 - b. Flex-Strut Inc.
 - c. Thomas & Betts Corporation; A Member of the ABB Group.
 - d. Unistrut; Part of Atkore International.
 - e. Wesanco, Inc.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with intumed lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.

7. Metallic Coating: Electroplated zinc, Hot-dipped galvanized, Mill galvanized, In-line, hot galvanized, or Mechanically-deposited zinc.
8. Paint Coating: Epoxy or Alkyd.
9. Plastic Coating: PVC or Polyurethane.
10. Combination Coating: .

B. Non-MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International.
 - b. ERICO International Corporation.
 - c. PHD Manufacturing, Inc.
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.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel or stainless steel.
7. Coating: Zinc, Paint or PVC.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Clement Support Services.
 2. ERICO International Corporation.
 3. National Pipe Hanger Corporation.
 4. Pipe Shields Inc.
 5. Piping Technology & Products, Inc.
 6. Rilco Manufacturing Co., Inc.
- B. Insulation-Insert Material for Hot and cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig minimum compressive strength.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

- A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- B. Mechanical-Expansion Anchors: Insert-wedge-type, stainless- 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. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Stainless steel.
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Non staining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.
- C. Flashing:
Metal Flashing: 26gage galvanized steel.
1. Metal Counterflashing: 22 gage thick galvanized steel.
 2. Flexible Flashing: 47 mil thick sheet butyl or other material compatible with roofing. Verify with roofing manufacturer.
 3. Caps: Steel, 22-gage minimum; 16 gage at fire resistant elements.
- D. Sleeves:
1. Ductwork Sleeve 18-gauge Installation and Closure for Fire Rated Walls and Floors: Fire damper assembly with continuous angles on all sides as per NFPA-90A requirements.
 2. Provide and install sleeves for all penetrations in accordance with Division 1.
- E. Escutcheons:
1. Chrome plated cast brass escutcheons with set screws on all exposed piping at wall penetrations in finished spaces.
- F. Hanger Rods:
1. Hanger Rods: Hot rolled steel threaded both ends, threaded one end, or continuous threaded. In accordance with the following schedule.

HANGER ROD SIZE SCHEDULE	
Pipe Size (in)	Min Rod Dia (in)
3/4" to 2"	3/8"
1/2" to 3-1/2"	1/2"
4" to 5"	5/8"
6"	3/4"
8" to 12"	7/8"
14"	1"
16" to 18"	1-1/8"
20"	1-1/4"
24"	1-1/2"
30"	1-7/8"

2. Hanger spacing shall be in accordance with the following schedule for maximum allowable distance. Provide hanger all changes in direction.

PIPE SUPPORT SPACING SCHEDULE		
Pipe Material/ Size (in)	Maximum Horizontal Spacing (ft)	Maximum Vertical Spacing (ft)
Steel		
Up to 1 ¼"	8	15
1 ½" to 2 ½"	10	15
3" and over	12	15
Copper Pipe	8	10
Copper Tubing		
Up to 1 ¼"	6	10
1 ½" and over	8	10
PVC / HDPE		
Up to 1"	3	10
1 1/4" and over	4	10

3. Fiberglass piping supports spacing shall be in accordance with the manufacture's guidelines.

2.9 VIBRATION ISOLATION HANGERS

- A. Vibration isolation pipe hangers: pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc

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 thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- G. 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 on all piping with roller hangers installed outside of insulation. 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 not on roller hangers. 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 same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

3.3 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

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

3.4 ADJUSTING

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

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply cold galvanizing-repair paint to comply with ASTM A 780. ZRC cold galvanizing compound

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 or metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
- F. Use stainless-steel pipe hangers and stainless-steel attachments for hostile environment applications.
- G. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
- H. Use padded hangers for piping that is subject to scratching.
- I. Use thermal-hanger shield inserts for insulated piping and tubing.
- J. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated 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. 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.
 - 5. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
 - 6. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated, stationary pipes NPS 1/2 to NPS 8.
 - 7. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated, stationary pipes NPS 3/8 to NPS 3.
 - 8. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
 - 9. 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.
 - 10. 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.
 - 11. 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 might occur.
 - 12. 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 might occur.
 - 13. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

14. 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 might occur and vertical adjustment is not necessary.
 15. 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 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.
 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.
- 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 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.
- 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-joint 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. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 9. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 10. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 11. 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.
12. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 13. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- N. 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.
- O. 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.
 9. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20' or the first two hangers.
- P. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.

- Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- R. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.7 MISCELLANEOUS:

- A. Equipment bases and supports.
 - 1. Provide housekeeping pads of concrete, minimum 4 inches thick and extending 6 inches beyond supported equipment. Changers edges all four side. Provide dowels into concrete floor for equipment that is seismically braced.
 - 2. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment. Provide for all equipment, pumps, air handling units, etc.
 - 3. Construct supports of steel members. Brace and fasten with flanges bolted to structure.
Provide rigid anchors for pipes after vibration isolation components are installed.
- B. Flashing:
 - 1. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
 - 2. Flash piping projecting above finished roof surface with prefabricated steel reinforced boot and counter flashing sleeve.
- C. Sleeves:
 - 1. Sleeves are required for all piping passing through walls and/or slabs. Sleeve diameter to be large enough to accommodate insulated piping.
 - 2. Sleeves through interior non-fire rated walls are to have annular space between pipe and sleeve filled with materials specified in Division 1.
 - 3. Sleeves thru fire rated walls to have annular space filled with fire stopping wrapping strips and expanding caulking applied with a caulking gun for a minimum depth of 3" or in another manner suitable for the application as recommended by the manufacturer.
See Division 1.
- D. Escutcheons:
 - 1. Provide escutcheons on all wall pipe penetrations that are visible outside MER spaces. All escutcheons shall be chrome plated.

END OF SECTION

SECTION 23 05 48.13

VIBRATION CONTROLS 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. Vibration isolation for piping, ductwork, and equipment.
 - 2. Equipment isolation bases.
 - 3. Flexible piping connections.
 - 4. Resilient Pipe Anchors and Guides.
- B. Related Requirements:
 - 1. Section 210548.13 "Vibration Controls for Fire Suppression" for devices for fire-suppression equipment and systems.
 - 2. Section 220548.13 "Vibration Controls for Plumbing" for devices for plumbing equipment and systems.

1.3 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 type required.
- B. Shop Drawings:
 - 1. Detail fabrication and assembly of equipment bases. Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
 - 2. 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.

INFORMATIONAL SUBMITTALS

- C. Coordination Drawings: Show coordination of vibration isolation device installation for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and restraints, if any.
- D. Qualification Data: For testing agency.
- E. Welding certificates.
- F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data performed by an independent agency.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-spring mounts and restrained-air-spring mounts to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURES

- 1. Manufacturers: The basis of this specification shall be Mason Industries. Other manufactures that may be considered subject to compliance with these specifications, shall be by one of the following approved vendors:
 - a. Kinetics Noise Control, Inc.
 - b. Vibration Mounting and Controls.
 - c. Vibration Eliminator Co., Inc.
 - d. Vibration Isolation.

2.2 PRODUCT DESCRIPTION (SPECIFICATION DESIGNATION)

- A. Neoprene mountings shall have a minimum static deflection of 0.35". All metal surfaces shall be neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang. Mountings shall be type ND or rails type DNR as manufactured by Mason Industries, Inc
- B. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4" neoprene acoustical friction pad between

the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be type SLF, as manufactured by Mason Industries, Inc

- C. Multiple bellow air springs shall be manufactured with powder coated upper and lower steel sections connected by a replaceable, flexible Nylon reinforced Neoprene element to achieve a maximum natural frequency of 3 Hz. Burst pressure must be a minimum of 3 times the published maximum operating pressure. All air spring systems shall be equipped with 3 leveling valves connected to the building control air or a supplementary air supply to maintain elevation plus or minus 1/8". An air filter and water separator shall be installed before the air distribution system to the leveling valves. Submittals shall include natural frequency, as well as load and damping tests, all as performed by an independent lab or acoustician. Air springs shall be type MT and leveling valves type LV as manufactured by Mason Industries, Inc.
- D. Equipment with large variations in the operating and installed weight, such as chillers, boilers, etc., and equipment exposed to the wind such as cooling towers, roof mounted fans and roof mounted air handling equipment shall be mounted on spring mountings, as described in Engineering Specification B, including the neoprene acoustical pad within a rigid sided housing that includes vertical limit stops to prevent spring extension when weight is removed and temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection. When the equipment is at full operating weight, the springs shall be adjusted to assume the weight and the spacers removed, without changing the installed and operating heights. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as horizontal modes. The hole through the bushing shall be a minimum of 0.75" larger in diameter than the restraining bolt. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of 0.5" to avoid bumping and interfering with the spring action. Vertical limit stops shall be out of contact during normal operation. Cooling tower mounts are to be located between the supporting steel and the roof or the grillage and dunnage as shown on the drawings when there is no provision for direct mounting. Housings and springs shall be powder coated and hardware electro galvanized. Mountings shall be SLR as manufactured by Mason Industries, Inc.
- E. Equipment with large variations in the operating and installed weight, such as chillers, boilers, etc., and equipment exposed to the wind such as cooling towers, roof mounted fans and roof mounted air handling equipment shall be mounted on air springs, as described in Engineering Specification C, but within a rigid sided housing that includes vertical limit stops to prevent spring extension when weight is removed and temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection. When the equipment is at full operating weight, the air springs shall be pressurized to take the weight so the spacers can be removed without changing the installed and operating heights. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as the horizontal modes. The hole through the bushing shall be a minimum of 0.75" larger in diameter than the restraining bolt. Horizontal clearance between the air spring assembly and the housing shall be a

minimum of 0.5" to avoid bumping and interference with the air spring action. Vertical limit stops shall be out of contact during normal operation. Mountings and air spring parts shall be powder coated. Hardware electro-galvanized. Air spring systems shall be connected to the building control air or a supplementary air supply and equipped with three leveling valves to maintain level within plus or minus 0.125". Cooling tower mounts are to be located between the supporting steel and the roof or the grillage and dunnage as shown on the drawings when there is no provision for direct mounting. Mountings shall be SLR-MT and leveling valves type LV as manufactured by Mason Industries, Inc.

- F. Hangers shall consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top and a steel spring with general characteristics as in specification B seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing and short circuiting the spring. Submittals shall include a hanger drawing showing the 30° capability. Hangers shall be type 30N as manufactured by Mason Industries, Inc.
- G. Hangers shall be as described in F, but they shall be pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.
- H. Hangers shall be manufactured with minimum characteristics as in Specification B, but without the neoprene element. Springs are seated in a steel washer reinforced neoprene cup that has a neoprene bushing projecting through the bottom hole to prevent rod to hanger contact. Spring diameters and the lower hole sizes shall be large enough to allow the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing.

If ducts are suspended by flat strap iron, the hanger assembly shall be modified by the manufacturer with an eye on top of the box and on the bottom of the spring hanger rod to allow for bolting to the hanger straps. Submittals on either of the above hangers shall include a scale drawing of the hanger showing the 30° capability. Hangers for rods shall be Type 30 or for straps W30 as manufactured by Mason Industries, Inc.

- I. Where specified or where the total air thrust exceeds 10% of the isolated weight, floor mounted or suspended air handling equipment shall be protected against excessive displacement using horizontal thrust restraints. The restraint shall consist of a modified Specification B spring mounting. Restraint springs shall have the same deflection as the isolator springs. The assembly shall be preset at the factory and fine-tuned in the field to allow for a maximum of 1/4" movement from stop to maximum thrust. The assemblies shall be furnished with rod and angle brackets for attachment to both the equipment and duct work or the equipment and the structure. Restraints shall be

attached at the center line of thrust and symmetrically on both sides of the unit. Horizontal thrust restraints shall be WB as manufactured by Mason Industries, Inc.

- J. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped. Pump bases for split case pumps shall be large enough to support suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14" provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1". Bases shall be type WF as manufactured by Mason Industries, Inc.
- K. Vibration isolation manufacturer shall provide steel members welded to height saving brackets to cradle equipment having legs or bases that do not require a complete supplementary base. Members shall have sufficient rigidity to prevent distortion of equipment. Inverted saddles shall be type ICS, as manufactured by Mason Industries, Inc.
- L. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating concrete bases. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6". The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1" clearance below the base. Wooden formed bases leaving a concrete rather than a steel finish are not acceptable. Base shall be type BMK or K as manufactured by Mason Industries, Inc.
- M. Curb mounted rooftop equipment shall be mounted on vibration isolation bases that fit over the roof curb and under the isolated equipment. The extruded aluminum top member shall overlap the bottom to provide water runoff independent of the seal. Aluminum members shall house electro galvanized or powder coated springs selected for 0.75" minimum deflection. Travel to solid shall be 1.5" minimum. Spring diameters shall be no less than 0.8 of the spring heights at rated load. Wind resistance shall be provided by means of resilient snubbers in the corners with a minimum clearance of 1/4" so as not to interfere with the spring action except in high winds. Manufacturer's self-adhering closed cell sponge gasketing must be used both above and below the base and a flexible EPDM duct like connection shall seal the outside perimeter. Foam or other sliding or shear seals are unacceptable in lieu of the EPDM duct-like enclosure. Submittals shall include spring deflections, spring diameters, compressed spring height and solid spring height as well as seal and wind resistance details. Curb mounted bases shall be Type CMAB as manufactured by Mason Industries, Inc.
- N. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of galvanized steel Z section or channel containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to

resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware must be plated, and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curb's waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc

- O. Rubber expansion joints shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. Substitutions must have certifiable equal or superior characteristics. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 16" through 24" may be single sphere. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.

Minimum ratings through 14" shall be 250psi at 170°F and 215psi at 250°F. and at 16" 180psi at 170°F and 150psi at 250°F. Higher published rated connectors may be used where required.

Safety factors shall be a minimum of 3/1. All expansion joints must be factory tested to 150% of maximum pressure for 12 minutes before shipment. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them. Submittals shall include two test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc

- P. Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes may have male nipples.

Q.

Minimum Flanged

3" x 12"	6" x 18"	12" x 24"
4" x 12"	8" x 18"	14" x 30"
5" x 18"	10" x 18"	16" x 32"

Male Nipples

1/2" x 12"	1-1/4" x 12"	2" x 12"
3/4" x 12"	1-1/2" x 12"	2-1/2" x 18"
1" x 12"		

At equipment, hoses shall be installed on the equipment side of the shut-off valves horizontal and parallel to the equipment shafts wherever possible. Hoses shall be type FFL or type MN as manufactured by Mason Industries, Inc

- R. Split Seals consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall, or ceiling if the seal is not in place prior to the construction of the building member. Seals shall project a minimum of 1" past face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.
- S. All directional acoustical pipe anchors consist of two sizes of steel tubing separated by a minimum 1/2" thickness of 60 duro or softer neoprene. Vertical restraint shall be provided by similar material arranged to prevent up or down vertical travel. Allowable loads on the isolation material shall not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All directional anchors shall be type ADA as manufactured by Mason Industries, Inc.
- T. Pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum 1/2" thickness of 60 durometer or softer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Guides shall be capable of 1-5/8" motion, or to meet location requirements. Pipe guides shall be type VSG as manufactured by Mason Industries, Inc.
- U. Pipe Isolation: The first four pipe hangers in the main lines near the mechanical equipment (including pumps), shall be isolated in accordance with specification Type G. Hangers supporting piping 2" and larger in all other locations throughout the building shall be isolated by hangers as described in specification F. Floor supported piping shall rest on isolators as described in specification D. Heat exchangers and expansion tanks are considered part of the piping run. The first four isolators from the isolated equipment shall have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first four hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1-1/2" deflection for pipe sizes over 3" and up to and including 6", and 2-1/2" deflection thereafter. Where piping connects to mechanical equipment install specification O expansion joints or specification P stainless hoses if O is not suitable for the service. All piping passing through the equipment walls, floors or ceilings shall be protected against sound leakage by means of an acoustical seal, as described in Specification Q.
- V. Duct Isolation: All air ducts with a cross section of 2 SF or larger shall be isolated from the building structure by specification H hangers or B floor supports with a minimum deflection of 0.75". Isolators shall continue for 25' from the equipment. If air velocity exceeds 1500 fpm, hangers or supports shall continue for an additional 50' or as shown on the drawings.

- W. Elastomeric hangers in a Steel Frame with Upper and Lower Steel Hanger Rods.
Frame: Steel, fabricated with a connection for an upper threaded hanger rod and an opening on the underside to allow for a maximum of 30 degrees of angular lower hanger-rod misalignment without binding or reducing isolation efficiency.
Dampening Element: Molded, oil-resistant rubber, neoprene, or other elastomeric material with a projecting bushing for the underside opening preventing steel to steel contact.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation 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 VIBRATION CONTROL 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
- B. Installation of vibration isolators must not cause any change of position of equipment, piping, or ductwork resulting in stresses or misalignment.

3.3 AIR-SPRING ISOLATORS INSTALLATION (NOT USED)

- A. Independent Isolator Installation:
 - 1. Install tank valve into each air isolator.
 - 2. Inflate each isolator to height and pressure specified on Drawings.
- B. Pressure-Regulated Isolator Installation:
 - 1. Coordinate the constant pressure-regulated air supply to air springs with the requirements for piping and connections specified in Section 221513 "General-Service Compressed-Air Piping."
 - 2. Connect all pressure regulators to a single dry, filtered constant air supply.
 - 3. Inflate isolators to height and pressure specified on Drawings.

3.4 VIBRATION ISOLATION EQUIPMENT BASES INSTALLATION

- A. Coordinate the location of embedded connection hardware with supported equipment attachment and mounting points and with requirements for concrete reinforcement and formwork specified in Section 033000 "Cast-in-Place Concrete." Section 033053 "Miscellaneous Cast-in-Place Concrete."

3.5 GENERAL

- A. All vibration isolators must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
- B. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.
- C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.
- D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.
- E. Coordinate work with other trades to avoid rigid contact with the building.
- F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the engineer's attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.
- G. Bring to the engineer's attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.
- H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.
- I. Where piping passes through walls, floors, or ceilings the vibration isolation manufacturer shall provide 2.02-Q seals.
- J. Locate isolation hangers as near to the overhead support structure as possible.
- K. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust when thrust forces exceed 10% of the equipment weight. Horizontal thrust restraints shall be 2.02-I restraints.
- L. Rooftop equipment isolators must be bolted to the equipment and structure. Mountings must be designed to resist 100m/h wind loads.

3.6 Vibration Isolation of Piping

- A. Horizontal pipe shall be installed in accordance with 2.02-T Horizontal Pipe Isolation.
- B. Risers shall be installed in accordance with 2.02-U Riser Isolation.

3.7 Vibration Isolation of Ductwork

- A. All duct runs shall be installed in accordance with 2.02-V Duct Isolation

PART 4 – VIBRATION ISOLATION SCHEDULE FOR NON-SEISMIC DESIGN

VIBRATION ISOLATION SCHEDULE		
Equipment	Vibration Isolator and/or Restraint	
	Specification/ Model	Static Deflection*
Inline hanging fans/fan-coil units	F – 30N	1.5"
Hanging Air Handling Units	F – 30N	1.5"
Pad mounted Air handling Units	B-SLF	1.5
Stand mounted Air handling Unit	A – ND	1.5"
Hydronic Water pumps	L -BMK concrete base – with B-SLF springs	1.0"
Pump pipe connections	O - SFDEJ	Double
Hydronic pipe connection	B-BSS	
Pipe Hangers	P- PC30N	1.5

END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 WORK INCLUDED

- A. Identification of mechanical products installed under Division 23.

1.2 REFERENCES

- A. ASME A13.1 – Scheme for the Identification of Piping Systems

1.3 SUBMITTALS

- A. Submittals as per contract requirements.
- B. See Division 1 list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Manufacturer's Instructions: Indicate installation instructions, special procedures, and installation.
- E. Project Record Documents: Record actual locations of tagged valves; include valve tag numbers.
- F. Valve Tag chart.

PART 2 PRODUCTS

2.1 NAMEPLATES, TAGS, MARKERS, ETC

- A. Manufacturer: W.H. Brady Co., Signmark Div
- B. Acceptable manufacturers offering equivalent products
 - 1. Atlantic Engraving Company.
 - 2. Seton Name Plate Co.
 - 3. MSI Services
 - 4. Substitutions as per Contract Requirements.
- C. Description: Nameplates should be as specified in Division 1.

PART 3 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials
- B. Prepare surfaces in accordance with contract requirements.

3.2 INSTALLATION

- A. Install tags, markers, etc. in conformance with Division 1.
- B. Unless otherwise specified, color shall conform with ANSI/ASME A13.1
- C. Install identifying devices after completion of coverings and painting.
- D. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive.
- E. Install labels with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer. For unfinished cloth covering, apply paint primer before applying labels.
- F. Install tags using corrosion resistant chain. Number tags consecutively by location.
- G. Apply stencil painting in accordance with contract requirements.
- H. Identify all equipment, including pumps, air handlers, air cooled condensers, boilers, chillers, pumps, packaged AC units, and hot water heater with nameplates. Small devices, such as in-line pumps, may be identified with metal tags. Identify service of all air handling units, packaged roof top units, ac units, and split systems. I.E. Ground floor offices. A plastic lamacoid placard shall be fastened to each unit with a full list of all the rooms served by that unit.
- I. Identify control panels and major control components outside panels with nameplates.
- J. Identify valves in main and branch piping with brass tags. Main shutoff valves for boiler shall be furnished with special wording as required by ASME IV HG 710.5 "Supply or Return Valve No. X - Do Not Close Without Also Closing Supply or Return Valve No. Y". Tags shall be provided for all new HVAC and related systems valves. Including heating water, CW make-up. This shall apply to new valves and on re-piped existing equipment such as the fuel oil system.
- K. Tag automatic controls, instruments, and relays. Key to control schematic.
- L. Identify piping, concealed or exposed, with markers. Use tags on piping 3/4-inch diameter and smaller. Identify service, flow direction, and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and tee,

at each side of penetration of structure or enclosure, and at each obstruction. Labeling shall be in conformance with OSHA and ANSI A13.1.

- M. Identify all ductwork every 20' with flow arrows and unit or air handler served as well as service, such as SUPPLY AIR, RETURN AIR, EXHAUST AIR. Etc
- N. All smoke purge system components (including supply and exhaust ductwork) shall be clearly identified as such by stenciling the function and zone on the components, e.g., Smoke Purge Supply - Zone 2; Smoke Purge Exhaust - Zone 3; Smoke Damper No. 5; etc. Stenciling shall be 6" high red letters located (every 10 feet along duct).
- O. Identify all Smoke Dampers and Fire Dampers. All dampers shall be sequentially numbered by floor. For example, fire damper - FD-1-1 (Fire damper #1, floor 1) Tag shall be 1" high red letters located on damper. Provide red dot stencil on ceiling below damper.
- P. Provide permanent labels for all controls and limits which state function of each control and control set points.

3.3 SCHEDULE

- A. Provide valve chart and schedule minimum of 8.5" x 11" in aluminum frame with clear laminate face. Install in the boiler room or at location as directed by the facilities. Indicate Valve #, size, Service and N.O. or N.C.

VALVE TAG SCHEDULE			
No.	size	Service	N.O./N.C.

The chart shall contain all new HVAC and related systems valves, new. Including heating water, chilled water, and CW make up, and drain.

END OF SECTION

SECTION 23 05 93

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. Variable-flow hydronic systems.
 - b. Primary-secondary hydronic systems.
- 3. Testing, Adjusting, and Balancing Equipment:
 - a. Motors.
 - b. Condensing units.
 - c. Boilers.
 - d. Air handling units
 - e. Packaged roof top units
- 4. Testing, adjusting, and balancing existing systems and equipment.
- 5. Duct leakage tests.
- 6. Control system verification.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. BAS: Building automation systems.
- C. NEBB: National Environmental Balancing Bureau.
- D. TAB: Testing, adjusting, and balancing.
- E. TABB: Testing, Adjusting, and Balancing Bureau.

- F. TAB Specialist: An independent entity meeting qualifications to perform TAB work.
- G. TDH: Total dynamic head.

1.4 PREINSTALLATION MEETINGS

- A. TAB Conference: If requested by the engineer, conduct a TAB conference at Project site after approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Provide a minimum of 14 days' advance notice of scheduled meeting time and location.
 - 1. Minimum Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plans.
 - c. Needs for coordination and cooperation of trades and subcontractors.
 - d. Proposed procedures for documentation and communication flow.

1.5 ACTION SUBMITTALS

- A. Sustainable Design Submittals:
 - 1. Air-Balance Report: Documentation indicating that Work complies with ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
 - 2. TAB Report: Documentation indicating that Work complies with ASHRAE/IES 90.1, Section 6.7.2.3 - "System Balancing."

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.
- C. Certified TAB reports.
- D. Sample report forms.
- E. 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.

1.7 QUALITY ASSURANCE

- A. TAB Specialists Qualifications: Certified by AABC NEBB or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB specialist and certified by AABC or NEBB or TABB.
 - 2. TAB Technician: Employee of the TAB specialist and certified by AABC or NEBB as a TAB technician.
- B. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

1.8 FIELD 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.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems designs that may preclude proper TAB of systems and equipment.
- B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- F. Examine equipment performance data including fan and pump curves.

1. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
 2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
- G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- H. Examine test reports specified in individual system and equipment Sections.
- I. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, filters are clean, and equipment with functioning controls is ready for operation.
- J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible, and their controls are connected and functioning.
- K. Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations.
- L. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows.
- M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine operating safety interlocks and controls on HVAC equipment.
- P. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes the following:
1. Equipment and systems to be tested.
 2. Strategies and step-by-step procedures for balancing the systems.
 3. Instrumentation to be used.
 4. Sample forms with specific identification for all equipment.
- B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:
1. Airside:

- a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
- b. Duct systems are complete with terminals installed.
- c. Volume, smoke, and fire dampers are open and functional.
- d. Clean filters are installed.
- e. Fans are operating, free of vibration, and rotating in correct direction.
- f. Variable-frequency controllers' startup is complete and safeties are verified.
- g. Automatic temperature-control systems are operational.
- h. Ceilings are installed.
- i. Windows and doors are installed.
- j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

- a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
- b. Piping is complete with terminals installed.
- c. Water treatment is complete.
- d. Systems are flushed, filled, and air purged.
- e. Strainers are pulled and cleaned.
- f. Control valves are functioning per the sequence of operation.
- g. Shutoff and balance valves have been verified to be 100 percent open.
- h. Pumps are started and proper rotation is verified.
- i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
- j. Variable-frequency controllers' startup is complete and safeties are verified.
- k. Suitable access to balancing devices and equipment is provided.

3.3 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.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping 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 ALL SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
- E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling-unit components.
- L. Verify that air duct system is sealed as specified in Section 233113 "Metal Ducts."
- M. Code requirements:

Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the International Mechanical Code. Discharge dampers used for air-system balancing are prohibited on constant-volume fans and variable volume fans with motors 10 hp and larger. Air systems shall be balanced in a manner to first minimize throttling losses then, for fans with system power greater than 1 hp, fan speed shall be adjusted to meet design flow conditions.

Therefore, all fans greater than 10 hp shall be provided with variable frequency drives for speed control.

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. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
 2. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report artificial loading of filters at the time static pressures are measured.
 3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
 4. Obtain approval from engineer for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.
1. Measure airflow of submain and branch ducts.
 2. Adjust submain and branch duct volume dampers for specified airflow.
 3. Re-measure each submain and branch duct after all have been adjusted.
- C. Adjust air inlets and outlets for each space to indicated airflows.
1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
 2. Measure inlets and outlets airflow.
 3. Adjust each inlet and outlet for specified airflow.
 4. Re-measure each inlet and outlet after they have been adjusted.
- D. Verify final system conditions.
1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
 2. Re-measure and confirm that total airflow is within design.

3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:
 - a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
 - b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
 - c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
 - d. Adjust controls so that terminal is calling for minimum airflow.
 - e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.
 - f. When in full cooling or full heating, ensure that there is no mixing of hot-deck and cold-deck airstreams unless so designed.
 - g. On constant volume terminals, in critical areas where room pressure is to be maintained, verify that the airflow remains constant over the full range of full cooling to full heating. Note any deviation from design airflow or room pressure.
5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.
 - a. Set outside-air, return-air, and relief-air dampers for proper position that simulates minimum outdoor-air conditions.
 - b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.

- c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
 - d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
 - e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.
- 6. Measure fan static pressures as follows:
 - a. Measure static pressure directly at the fan outlet or through the flexible connection.
 - b. Measure static pressure directly at the fan inlet or through the flexible connection.
 - c. Measure static pressure across each component that makes up the air-handling system.
 - d. Report any artificial loading of filters at the time static pressures are measured.
- 7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
 - b. Verify that terminal units are meeting design airflow under system maximum flow.
- 8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
- 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
 - b. Re-measure and confirm that total airflow is within design.
 - c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
 - d. Mark final settings.
 - e. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data.
 - f. Verify tracking between supply and return fans.

3.7 GENERAL PROCEDURES FOR ALL HYDRONIC SYSTEMS

- A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.
- B. Prepare schematic diagrams of systems' "as-built" piping layouts.

- C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:
1. Check liquid level in expansion tank.
 2. Check highest vent for adequate pressure.
 3. Check flow-control valves for proper position.
 4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
 5. Verify that motor starters are equipped with properly sized thermal protection.
 6. Check that air has been purged from the system.
- D. Code requirements:
1. Individual hydronic heating and cooling coils shall be equipped with means for balancing and measuring flow. Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses, then the pump impeller shall be trimmed, or pump speed shall be adjusted to meet design flow conditions. Each hydronic system shall have either the capability to measure pressure across the pump, or test ports at each side of each pump.

3.8 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

- A. Adjust pumps to deliver total design GPM.
1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- B. Adjust flow-measuring devices installed in mains and branches to design water flows.
1. Measure flow in main and branch pipes.
 2. Adjust main and branch balance valves for design flow.

3. Re-measure each main and branch after all have been adjusted.
- C. Adjust flow-measuring devices installed at terminals for each space to design water flows.
1. Measure flow at terminals.
 2. Adjust each terminal to design flow.
 3. Re-measure each terminal after it is adjusted.
 4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
 5. Perform temperature tests after flows have been balanced.
- D. For systems with pressure-independent valves at terminals:
1. Measure differential pressure and verify that it is within manufacturer's specified range.
 2. Perform temperature tests after flows have been verified.
- E. For systems without pressure-independent valves or flow-measuring devices at terminals:
1. Measure and balance coils by either coil pressure drop or temperature method.
 2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
- F. Verify final system conditions as follows:
1. Re-measure and confirm that total water flow is within design.
 2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 3. Mark final settings.
- G. Verify that memory stops have been set.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

- A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.
- B. Adjust the variable-flow hydronic system as follows:
1. Verify that the differential-pressure sensor is located as indicated.
 2. Determine whether there is diversity in the system.
- C. For systems with no diversity:
1. Adjust pumps to deliver total design GPM.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.

- 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
2. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.
 - c. Re-measure each main and branch after all have been adjusted.
3. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
4. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
5. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

6. Prior to verifying final system conditions, determine the system differential-pressure set point.
 7. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
 8. Mark final settings and verify that all memory stops have been set.
 9. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - c. Mark final settings.
 10. Verify that memory stops have been set.
- D. For systems with diversity:
1. Determine diversity factor.
 2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.
 3. Adjust pumps to deliver total design GPM.
 - a. Measure total water flow.
 - 1) Position valves for full flow through coils.
 - 2) Measure flow by main flow meter, if installed.
 - 3) If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - b. Measure pump TDH as follows:
 - 1) Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - 2) Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - 3) Convert pressure to head and correct for differences in gage heights.
 - 4) Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 5) With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - c. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
 4. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - a. Measure flow in main and branch pipes.
 - b. Adjust main and branch balance valves for design flow.

- c. Re-measure each main and branch after all have been adjusted.
 - 5. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - a. Measure flow at terminals.
 - b. Adjust each terminal to design flow.
 - c. Re-measure each terminal after it is adjusted.
 - d. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 - e. Perform temperature tests after flows have been balanced.
 - 6. For systems with pressure-independent valves at terminals:
 - a. Measure differential pressure and verify that it is within manufacturer's specified range.
 - b. Perform temperature tests after flows have been verified.
 - 7. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - a. Measure and balance coils by either coil pressure drop or temperature method.
 - b. If balanced by coil pressure drop, perform temperature tests after flows have been verified.
 - 8. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance terminals that were just opened.
 - 9. Prior to verifying final system conditions, determine system differential-pressure set point.
 - 10. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.
 - 11. Mark final settings and verify that memory stops have been set.
 - 12. Verify final system conditions as follows:
 - a. Re-measure and confirm that total water flow is within design.
 - b. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
 - c. Mark final settings.
 - 13. Verify that memory stops have been set.
- 3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS
- A. Balance the primary circuit flow first.
 - B. Balance the secondary circuits after the primary circuits are complete.

- C. Adjust pumps to deliver total design GP.,.
 - 1. Measure total water flow.
 - a. Position valves for full flow through coils.
 - b. Measure flow by main flow meter, if installed.
 - c. If main flow meter is not installed, determine flow by pump TDH or exchanger pressure drop.
 - 2. Measure pump TDH as follows:
 - a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
 - b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
 - c. Convert pressure to head and correct for differences in gage heights.
 - d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
 - 3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.
- D. Adjust flow-measuring devices installed in mains and branches to design water flows.
 - 1. Measure flow in main and branch pipes.
 - 2. Adjust main and branch balance valves for design flow.
 - 3. Re-measure each main and branch after all have been adjusted.
- E. Adjust flow-measuring devices installed at terminals for each space to design water flows.
 - 1. Measure flow at terminals.
 - 2. Adjust each terminal to design flow.
 - 3. Re-measure each terminal after it is adjusted.
 - 4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
 - 5. Perform temperature tests after flows have been balanced.
- F. For systems with pressure-independent valves at terminals:
 - 1. Measure differential pressure and verify that it is within manufacturer's specified range.
 - 2. Perform temperature tests after flows have been verified.
- G. For systems without pressure-independent valves or flow-measuring devices at terminals:
 - 1. Measure and balance coils by either coil pressure drop or temperature method.

2. If balanced by coil pressure drop, perform temperature tests after flows have been verified.

H. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.

I. Verify that memory stops have been set.

3.11 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.12 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Measure entering- and leaving-air temperatures.
- C. Record fan and motor operating data.

3.13 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

B. Steam Boilers:

1. Measure and record entering-water temperature.
2. Measure and record feed water flow.
3. Measure and record leaving-steam pressure and temperature.

4. Record relief valve pressure setting.

3.14 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop for major (more than 20 GPM) equipment coils, excluding unitary equipment such as reheat coils, unit heaters, and fan-coil units.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.

- B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

- C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.
3. Inlet steam pressure.

- D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.15 DUCT LEAKAGE TESTS

- A. Ducts designed to operate at static pressures of 3 inches w.g. or greater shall be sealed in accordance with specifications Section 23 31 13 Metal Ducts. In addition, ducts and plenums shall be leak tested in accordance with the procedures given SMACNA *HVAC Air Duct Leakage Test Manual*. Air leakage rates must (CL) less than or equal to 4.0 as determined in accordance with Equations below:

1. $CL = F/P^{0.65}$ where:
2. F -The measured leakage rate in cfm per 100 square feet of duct surface.
3. P -The static pressure of the test.

- B. Documentation shall be furnished by the test and balancing contractor demonstrating that representative sections totaling at least 25 percent of the duct area have been tested and that all tested sections meet the requirements of this section.

- C. Perform duct pressure testing in coordination with Installer.
- D. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- E. Report: submit a report indicating which ductwork sections were tested. Provide single line or double line duct submittal drawing. The drawing shall indicate all systems in their entirety to 3/8" = 1'-0" scale. Sections that air leakage tested shall be clearly indicated.
- F. The report shall include full test procedure including how the ductwork was isolated for pressure testing, the pressure of the test and the duration of the test.
- G. Submit duct pressure test procedures used for this project.
- H. Submit summary of test results on a section by section basis, to include all CL, F, P and time.
- I. Witness the duct pressure testing performed by Installer.
- J. Verify that proper test methods are used and that leakage rates are within specified tolerances.
- K. Report deficiencies observed.

3.16 CONTROLS VERIFICATION

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

3.17 TOLERANCES

- A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus, or minus 10 percent.
 2. Air Outlets and Inlets: Plus, or minus 10 percent.
 3. Heating-Water Flow Rate: Plus, or minus 10 percent.
 4. Cooling-Water Flow Rate: Plus, or minus 10 percent.
- B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.18 PROGRESS REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.19 FINAL REPORT

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

6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
 2. Water 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, and bore.
- i. Center-to-center dimensions of sheave and amount of adjustments in inches.
- j. Number, make, and size of belts.
- k. Number, type, and size of filters.

2. Motor Data:

- a. Motor make, and frame type and size.
- b. Horsepower and rpm.
- c. Volts, phase, and hertz.
- d. Full-load amperage and service factor.
- e. Sheave make, size in inches, and bore.
- f. Center-to-center dimensions of sheave and number of adjustments in inches.

3. Test Data (Indicated and Actual Values):

- a. Total airflow rate in cfm.
- b. Total system static pressure in inches wg.
- c. Fan rpm.
- d. Discharge static pressure in inches wg.
- e. Filter static-pressure differential in inches wg.
- f. Preheat-coil static-pressure differential in inches wg.
- g. Cooling-coil static-pressure differential in inches wg.
- h. Heating-coil static-pressure differential in inches wg.
- i. Outdoor airflow in cfm.
- j. Return airflow in cfm.
- k. Outdoor-air damper position.
- l. Return-air damper position.
- m. 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 o.c.
- f. Make and model number.
- g. Face area in sq. ft.
- h. Tube size in NPS.
- i. Tube and fin materials.
- j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):

- a. Airflow rate in cfm.
- b. Average face velocity in fpm.

- c. Air pressure drop in inches wg.
 - d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
 - e. Return-air, wet- and dry-bulb temperatures in deg F.
 - f. Entering-air, wet- and dry-bulb temperatures in deg F.
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F.
 - h. Water flow rate in gpm.
 - i. Water pressure differential in feet of head or psig.
 - j. Entering-water temperature in deg F.
 - k. Leaving-water temperature in deg F.
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig.
 - n. Refrigerant suction temperature in deg F.
 - o. Inlet steam pressure in psig.
- G. Fan Test Reports: For supply, return, and exhaust fans, include the following:
- 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave and number of adjustments in inches.
 - 2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and number of adjustments in inches.
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- 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.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft.
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.
- I. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in sq. ft.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary airflow rate as needed in cfm.
 - d. Preliminary velocity as needed in fpm.
 - e. Final airflow rate in cfm.
 - f. Final velocity in fpm.
 - g. Space temperature in deg F.
- J. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
- 1. Unit Data:
 - a. System and air-handling-unit identification.
 - b. Location and zone.
 - c. Room or riser served.
 - d. Coil make and size.
 - e. Flowmeter type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Entering-water temperature in deg F.

- c. Leaving-water temperature in deg F.
 - d. Water pressures drop in feet of head or psig.
 - e. Entering-air temperature in deg F.
 - f. Leaving-air temperature in deg F.
- 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.
 - g. Water pressure differential in feet of head or psig.
 - h. Required net positive suction head in feet of head or psig.
 - i. Pump rpm.
 - j. Impeller diameter in inches.
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig.
 - b. Pump shutoff pressure in feet of head or psig.
 - c. Actual impeller size in inches.
 - d. Full-open flow rate in gpm.
 - e. Full-open pressure in feet of head or psig.
 - f. Final discharge pressure in feet of head or psig.
 - g. Final suction pressure in feet of head or psig.
 - h. Final total pressure in feet of head or psig.
 - i. Final water flow rate in gpm.
 - j. Voltage at each connection.
 - k. Amperage for each phase.
- L. Instrument Calibration Reports:
 - 1. Report Data:
 - a. Instrument type and make.
 - b. Serial number.
 - c. Application.
 - d. Dates of use.
 - e. Dates of calibration.

3.20 VERIFICATION OF TAB REPORT

- A. The TAB specialist's test and balance engineer shall conduct the inspection in the presence of commissioning authority.
- B. Commissioning authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- C. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- D. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- E. If TAB work fails, proceed as follows:
 - 1. TAB specialists shall recheck all measurements and adjust. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 - 2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.
- F. Prepare test and inspection reports.

3.21 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

SECTION 23 07 13

HVAC DUCTWORK INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Ductwork insulation.
- B. Duct Liner.
- C. Insulation jackets.

1.2 RELATED SECTIONS

- A. Section 23 05 53 - Identification for HVAC Piping and Equipment.
- B. Section 23 31 13 - Ductwork.

1.3 REFERENCES

- A. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- B. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- D. NAIMA National Insulation Standards.
- E. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- F. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
- G. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- H. ASHRAE 90-75 – Insulation Standards

1.4 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).
- 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.
 3. Product Data: For coatings, indicating VOC content.
 4. Laboratory Test Reports: For coatings, indicating compliance with requirements for low-emitting materials.
 5. Product Data: For sealants, indicating VOC content.
 6. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
 3. Detail application of field-applied jackets.
 4. Detail application at linkages of control devices.
- D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
1. Sheet Form Insulation Materials: 12 inches square.
 2. Sheet Jacket Materials: 12 inches square.
 3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.5 QUALITY ASSURANCE

- A. Applicator Qualifications: Company specializing in performing the work of this section with minimum three years' experience approved by manufacturer.

1.6 REGULATORY REQUIREMENTS

- A. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with NFPA 255.
- B. Insulation thickness shall comply with all applicable energy conservation codes.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - INSULATION

- A. Owen Corning Fiberglass Corp.

- B. Manville Industrial Products
- C. Certain Teed Corporation
- D. 3M Corporation "Firemaster" for Kitchen Exhaust
- E. Substitutions: Under provisions of Division 1.

2.2 GLASS FIBER, RIGID

- A. Type A: Flexible glass fiber duct insulation; ANSI/ASTM C612; commercial grade; "K" value of 0.25 at 75° F; minimum density of 1-1/2 pounds per cu. ft.; factory applied vapor barrier jacket of 0.7 mil minimum aluminum foil laminated to glass fiber reinforced Kraft paper. Similar to Owens-Corning type FRK-25-ED Type 150 commercial grade.
- B. Type B: Rigid glass fiber board insulation with resin binder; ANSI/ASTM C612, Class 1; "K" value of 0.23 at 75° F minimum density of 6 pounds per cu. ft; factory applied white Kraft faced flame retardant vapor barrier jacket of aluminum laminated to heavy Kraft paper with a flame-retardant snuffer type adhesive and reinforced with glass fibers; permeability of 0.2. Like Owens-Corning type 705 with AST jacket.
- C. Type C: Molded block or board insulation made of asbestos free hydrous calcium silicate; "K" value of 0.42 at 200° F; minimum density of 14 pounds per cubic foot; temperature range up to 1200° F.
- D. Type D1: Flexible Glass Duct Liner: (For standard applications)

ANSI/ASTM C553; "K" value of 0.23 at 75° F; minimum density of 1.5 pounds per cu. ft.; surface finish of black pigmented fire-resistant resilient mastic coated on air side for maximum velocity of 4000 feet per minute.

a. Maximum Thermal Conductivity

- 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.
- b. 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.
- c. Solvent Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.

- C. Type D2: Flexible Elastomeric Duct Liner: (Wet Or Damp Applications).

Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.

1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 2. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- D. Type "E" – Fire resistant duct wrap consisting of light weight, non-asbestos high temperature non-organic ceramic fiber blanket encapsulated in foil/scrim having a service temperature rating of 2300° F. Wrap shall be applied in two temperature layers to provide a two-hour rated enclosure assembly. Bonding material shall be 304 stainless steel, ¾" wide and .015" thick.
- E. Adhesives: Waterproof fire-retardant type. Smoke and flame spread rating less than 50.
- F. Indoor Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq. yd unless otherwise specified above.
- G. Outdoor Jackets: Insulate as per the specification and jacket with Polyguard Insul-wrap 50W Membrane. For watertight insulation jacket install as per manufacturers recommendations. Furnish all mastics and adhesives as per manufacture system.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Manufacturers: Subject to compliance with requirements, provide products by one of 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."
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 1. VOC Content: 300 g/L or less.
 - 2. Low-Emitting Materials: Mastic coatings 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."

2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F
 - 4. Color: Aluminum.
 - 5. Sealant shall have a VOC content of 420 g/L or less.
 - 6. 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."
- B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F
 - 4. Color: White.
 - 5. Sealant shall have a VOC content of 420 g/L or less.
 - 6. 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."

PART 3 EXECUTION

3.1 EXAMINATION

- A. Install insulation materials only after ductwork has been sealed, tested and approved.
- B. All insulated surfaces are to be cleaned and dried of any foreign material. This includes but is not limited to oil, water, dirt, rust and scale. Completely cover the entire surface to present a tight, smooth appearance.

3.2 INSTALLATION

- A. Division 1 - Quality Control: Install materials in accordance with manufacturer's instructions, specification requirements and in compliance with local code

- B. Install in accordance with NAIMA National Insulation Standards.
- C. Apply insulation in such a way as to permit expansion and/or contraction of metal without causing damage to insulation, joints, seams or finish.
- D. Do not apply additional coats of mastic, adhesive, or sealers until previous coats have thoroughly dried.
- E. Fill in all surface imperfections such as chipped edges, small joints, cracks, holes and small voids with materials to match insulation. Make smooth with a skim coat of insulation cement. Extend surface finish to protect all surfaces and leave no exposed edges.
- F. Provide flashing for insulation installed outdoors to enclose all exposed edges or ends.
- G. Repair existing insulation where damaged by new work. Use materials to match existing.
- H. Cut, score or miter insulation to fit the slope and contour of surface to be covered. Insulation up to 3 inches thick to be applied in single layer. Over 3 inches apply in multiple layers, with joints staggered.

3.3 DUCT INSULATION SCHEDULE

Service	Type	Insulation Thickness
¹ Interior H&V, AC systems; SA, RA & EA, ductwork that is exposed in equip rooms.	B	1-1/2"
¹ Interior H&V, AC systems; SA, RA & EA including flexible run outs, that is concealed.	A	2"
Outside air intake ductwork All	B	1 1/2"
² Exterior H&V, AC systems; SA, RA & RA, ductwork that that is exposed outdoors.	B	2"
Acoustically line all SA & RA ductwork For a distance of 20' from fan inlet and outlet and 10' downstream of all VAV boxes.	D1/D2	1/2"
⁵ Interior exposed H&V, AC systems; SA, RA located in conditioned spaces. rectangular, spiral round or oval ductwork.		
Located in conditioned space	D1/D2	1"
Located in unconditioned space, plenum or equipment room.	D1/D2	1 1/2"
⁴ Smoke purge exhaust and supply	E	2" (not used)

All Stair pressure ductwork	E	2" (not used)
Generator exhaust pipe and muffler	C	2" (not used)
Kitchen hood exhaust (grease duct) layers.	E	2" applied in (2) 1"

1. Insulation Thickness shall be no less than the size indicated or the height of standing seams or angle bracing.
2. On outdoor installations insulation thickness shall be as scheduled but not less than the height of standing seams or angle bracing. For indoor applications duct insulation can be reduced such that the total R-value of insulation is greater than or equal to R-8.
3. Outside air intake and Kitchen exhaust ducts shall not be internally lined.
4. Smoke purge system supply and exhaust ducts passing through a rated Exit-way or within a fire-rated suspended ceiling assembly and all Kitchen Hood exhaust ducts shall be wrapped with thermal fiber - two (2) hour or encased in a two (2) hour rated enclosure. Trapeze hangers to be outside of thermal wrapping.
5. All square, round, oval or rectangular ductwork that is exposed to view in finished spaces shall be internally insulated.

END OF SECTION

SECTION 23 07 16

HVAC EQUIPMENT INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Equipment insulation
- B. Covering
- C. Breeching insulation

1.2 RELATED SECTIONS

- A. Section 23 05 53 – Identification for HVAC Piping and Equipment.
- B. Section 23 21 13 - Hydronic Piping.
- C. Section 23 23 00 - Refrigerant Piping and Specialties.

1.3 REFERENCES

- A. ASHRAE 90-75 – Insulation Standards
- B. ASTM C195 – Standard Specification for Mineral Fiber Thermal Insulation Cement.
- C. ASTM C533 – Standard Specification for Calcium Silicate Block and Pipe Thermal
- D. ASTM C552 – Standard Specification for Cellular Glass Thermal Insulation.
- E. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
- G. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
- H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- I. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
- J. NAIMA National Insulation Standards.

- K. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials.
- L. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.4 SUBMITTALS FOR REVIEW

- A. Division 1 – Submittal Requirements.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.
- C. Manufacturer's Instructions: Indicate installation procedures which ensure acceptable workmanship and installation standards will be achieved.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
- C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail removable insulation at equipment connections.
 - 2. Detail application of field-applied jackets.
 - 3. Detail application at linkages of control devices.
 - 4. Detail field application for each equipment type.

1.6 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.7 REGULATORY REQUIREMENTS

- A. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50/50 in accordance with NFPA 255.
- B. Insulation thickness shall comply with applicable energy conservation codes.

1.8 DELIVERY, STORAGE, AND PROTECTION

- A. Division 1 - Material and Equipment: Transport, handle, store, and protect products.
- B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
- C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.9 ENVIRONMENTAL REQUIREMENTS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Owens Corning Fiberglass Corp.
- B. Certain Teed Corporation
- C. Manville Industrial Products.
- D. Substitutions: Under provisions of Section 01630.

2.2 INSULATION

- A. Type A: Flexible glass fiber blanket; ANSI/ASTM C553; 'k' value of 0.23 at 75° F, 3.5 lb/cu feet density. Temperature range - 35° F to 250° F.
- B. Type B: Rigid glass fiber board; ANSI/ASTM C612; 'k' value of 0.24 at 75° F, 6.0 lb/cu feet. Temperature range - 35° F to 250° F.
- C. Type C: Elastomeric insulation; ASTM C518, C177; 'K' Value of 0.27 at 75°F; non-combustible. Similar to Armstrong "AP Armaflex"; temperature range -40° F to 220°F.

2.3 ACCESSORIES

- A. Bedding Compounds: Non-shrinking, permanently flexible, compatible with insulation.
- B. Vapor Barrier Coating: Non-flammable, fire resistant, polymeric resin, compatible with insulation.
- C. Insulating Cement: ANSI/ASTM C195, hydraulic setting mineral wool
- D. Wire Mesh: Corrosive-resistant metal; hexagonal pattern.

2.4 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 Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.
 - 1. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.
 - 2. 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."
- C. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Adhesive: As recommended by Adhesive - PVC Jacket manufacturer and with a VOC content of 50 g/L or less.
 - 2. 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."

2.5 MASTICS AND COATINGS

- A. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.
 - 2. Mastics 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."

2.6 LAGGING ADHESIVES

- A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of Insert value g/L or less.
 - 2. 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."
 - 3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
 - 4. Service Temperature Range: 20 to plus 180 deg F Color: White.

2.7 SEALANTS

- A. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- B. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 58 to plus 176 deg F.
 - 3. Color: White or gray.
 - 4. Sealant shall have a VOC content of 420 g/L or less.
 - 5. 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."

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that equipment has been tested before applying insulation materials.
- B. Clean and dry all surfaces to be insulated of all foreign material. This includes but is not limited to water, oil, dirt, rust, and scale.

3.2 INSTALLATION

- A. Install materials in accordance with manufacturer's instruction, specification requirements and in compliance with local code.
- B. Only insulation and finish materials including adhesives, cements, and mastics which conform to the requirements of all governing codes & ordinances shall be used.
- C. Factory Insulated Equipment: Do not insulate.
- D. Exposed Equipment: Locate insulation and cover seams in least visible locations. Insulate expansion tanks, pumps, pot feeders etc.
- E. Apply insulation as close as possible to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands. Insulation shall be applied in single layers up to 3 inches thick; over 3 inches thick it shall be applied in multiple layers.
- F. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement. The surface finish shall be extended to protect all insulation surfaces. No raw edges or ends shall be left exposed.
- G. Insulated equipment containing fluids below ambient temperature: Insulate entire system.

- H. Cover insulation with metal mesh and finish with heavy coat of insulating cement.
- I. Insulation shall be applied in such a way as to permit expansion or contraction of metal without causing damage to insulation or surface finish. Seal or cement shall not be applied until all previous application of cements and adhesives have thoroughly dried.
- J. Vapor barrier finishes shall not be stapled through.
- K. Clean and dry all surfaces to be insulated of rust, scale, dirt, oil, water and other foreign matter. Apply insulation to completely cover metal surface. Surface finish shall be applied to present a tight, smooth appearance.
- L. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- M. Equipment Requiring Access for Maintenance, Repair, Cleaning: Install insulation so it can be easily removed and replaced without damage.
- N. Insulate all pumps with type C insulation. Fabricate custom aluminum sheet metal enclosure around pump body and fittings. Cut and fit insulation to tightly fit the size and shape of the pump body parts including the volute and inlet and outlet piping and fittings. The enclosure shall be removable without cutting or breaking the insulation. The enclosure shall be vapor tight to prevent condensation.

3.3 SCHEDULES

EQUIPMENT	INSULATION TYPE	THICKNESS
Air Handler Components and Fans, Not Factory insulated including coil & filter sections	B or C	1.5"
Return fans	B or C	1.5"
Expansion Tanks/Chemical Feed Tanks and heat exchangers All Specialties valves, air separators	C	1.5"
Boilers Factory Installed Jackets Factory Installed Jackets	B	2"
Pumps Body and Parts.	C	2"

END OF SECTION

SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Piping insulation
- B. Jackets and accessories

1.2 RELATED SECTIONS

- A. Section 23 05 53 – Identification for HVAC Piping and Equipment.
- B. Section 23 21 13 - Hydronic Piping.

1.3 REFERENCES

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus
- B. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
- C. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement
- D. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
- E. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
- F. ASTM C547 - Standard Specification for Mineral Fiber Preformed Pipe Insulation
- G. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.
- H. ASTM C578 - Standard Specification for Preformed, Cellular Polystyrene Thermal Insulation
- I. ASTM C610 - Standard Specification for Expanded Perlite Block and Pipe Thermal Insulation
- J. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

- K. NAIMA National Insulation Standards
- L. NFPA 255 - Standard Method of Test of Surface Burning Characteristics of Building Materials
- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- N. ASHRAE 90-75 - Insulation Standards

1.4 SUBMITTALS FOR REVIEW

- A. Division 1 – Submittal Requirements.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.
- D. Sustainable Design Submittals:
 - 1. Product Data: For adhesives, mastics, and sealants, indicating VOC content.
 - 2. Laboratory Test Reports: For adhesives, mastics, and sealants, indicating compliance with requirements for low-emitting materials.
- E. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail attachment and covering of heat tracing inside insulation.
 - 3. Detail insulation application at pipe expansion joints for each type of insulation.
 - 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 5. Detail removable insulation at piping specialties.
 - 6. Detail application of field-applied jackets.
 - 7. Detail application at linkages of control devices.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years' experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to maximum flame spread/smoke developed rating of 25/50 in accordance with NFPA 255.
- B. Insulation thickness shall comply with applicable Energy Conservation Codes.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

- A. Manufacturer: Pittsburgh Corning Corporation
- B. Certainteed Corporation.
- C. Armstrong Corporation.
- D. Manville Industrial Products.
- E. Owens-Corning Fiberglass Corporation
- F. Polyguard

2.2 INSULATION

- A. Type A: Molded glass fiber insulation; ANSI/ASTM C547; 'k' value of 0.23 at 75° F; noncombustible. Minimum density of 3.5 lbs./cu. Ft.; temperature range 35° F to 450° F.
- B. Type B: Cellular glass insulation; ASTM C552; 'K' Value of 0.53 at 75°F; non-combustible. Minimum density of 8.0 lbs./cu. ft. similar to Pittsburgh Corning Foamglas.
- C. Type C: Elastomeric insulation; ASTM C518, C177; 'K' Value of 0.27 at 75°F; non-combustible. Similar to Armstrong "AP Armaflex"; temperature range -40° F to 220° F
- D. Type D; Underground engineered pipe insulation system shall be as follows;
Service pipe insulation shall be spray applied .16k-factor, R141B blowing agent, nominal 2 pound per cubic foot density, polyurethane foam for straight sections and preformed polyurethane foam for all fittings. Insulation shall not be less than 2" and shall be Perma-pipe polytherm

2.3 JACKETS

- A. Interior Applications:
 - 1. Insulation Type A - Factory applied, white, flame retardant, all service (ASJ) vapor barrier jacket of .001" aluminum foil laminated to Kraft paper with a flame-retardant snuffer type adhesive reinforced with glass fibers and having a self-sealing lap. Provide 2" longitudinal lap and 4" circumferential sealing strips. Permeability .02 perm.
- B. Exterior Applications:

1. Insulation Type A thickness as scheduled with ASJ vapor barrier jacket - Cover factory interior jacket with Alumaguard Cool Wrap by Polyguard rubberized bitumen membrane designed specifically to be installed over insulation on exterior piping, tanks, vessels, and equipment. The membrane shall be 'peel and stick', self-healing if punctured, UV stable, and will expand and contract with the mechanical system. All seams shall be sealed watertight. Permeability .0053 perm

C. Piping exposed in Mechanical Rooms or any space:

1. All exposed piping and fittings shall be completely covered with white Zeston 2000 PVC insulated piping and fitting covers. Apply as per manufacturer with perma weld adhesive.

D. Underground applications: (not used)

All straight sections of the insulated piping system shall be filament wound; polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. The jacket shall be either filament wind fiberglass directly onto the polyurethane foam or injected foam into a fiberglass outer casing. Fiberglass outer casing shall be A.O. Smith Red Thread or Ameron Bondstrand 3000. Thermoplastic casing material that are not rated for temperatures above 140 degrees F will not be allowed, e.g., PVC or HDPE. The minimum thickness for FRP jacket shall be as 0.55."

2.4 ACCESSORIES

- A. Insulation Bands: ¾" wide; 0.007-inch-thick aluminum.
- B. Metal Jacket Bands: 3/8" wide; 0.015-inch-thick aluminum.
- C. Insulating Cement: ANSI/ASTM C195; hydraulic setting mineral wool.
- D. Finishing Cement: ASTM C449
- E. Fibrous Glass Cloth: Untreated; 9 oz/sq. yd weight.
- F. Adhesives: Compatible with insulation and fire retardant.

2.5 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 Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

1. Adhesive: As recommended by cellular glass manufacturer and with a VOC content of 80 g/L or less.
- C. Flexible Elastomeric and Polyolefin Adhesive: Solvent-based adhesive.
 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." Formaldehyde emissions shall not exceed 9 mcg/cu. m or 7 ppb, whichever is less.
 2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less as tested in accordance with ASTM E84.
 3. Wet Flash Point: Below 0 deg F.
 4. Service Temperature Range: 40 to 200 deg F
 5. Color: Black.
- D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 1. Adhesive: As recommended by mineral fiber manufacturer and with a VOC content of 80 g/L or less.

2.6 MASTICS AND COATINGS

- A. Mastic and coating terminology is used interchangeably in this article. Manufacturers refer to vapor-barrier formulations and vapor-retarder formulations as "mastics" or "coatings." Low-permeance mastics and coatings are termed "vapor retarders." Products with a perm rating of greater than 1.0 are called "breathable." Consider ambient conditions and operating temperatures when selecting mastics and coatings. Consider using water-based mastics and coatings for environmental reasons.
- B. Materials shall be compatible with insulation materials, jackets, and substrates.
 1. Mastics: As recommended by insulation manufacturer and with a VOC content of 50 g/L or less.

2.7 LAGGING ADHESIVES

- A. Adhesives shall comply with MIL-A-3316C, Class I, Grade A, and shall be compatible with insulation materials, jackets, and substrates.
 1. Adhesive shall be as recommended by insulation manufacturer and shall have a VOC content of 50 g/L or less.
 2. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
 3. In "Service Temperature Range" Subparagraph below, more manufacturers can comply if first option is retained; consult manufacturers.
 4. Service Temperature Range: 20 to plus 180 deg F.
 5. Color: White.

2.8 SEALANTS

- A. Sealants are categorized into "joint sealants" and "flashing sealants." Joint sealants are primarily used for vapor-sealing longitudinal seams and butt joints of insulation materials. Flashing sealants are primarily used for sealing jacket and mastic materials.
- B. Materials shall be as recommended by the insulation manufacturer and shall be compatible with insulation materials, jackets, and substrates.
- C. Joint Sealants:
 - 1. Permanently flexible, elastomeric sealant.
 - a. Service Temperature Range: Minus 150 to plus 250 deg F
 - b. Color: White or gray.
 - 2. Sealant shall have a VOC content of 420 g/L or less.
- D. FSK and Metal Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 40 to plus 250 deg F
 - 3. Color: Aluminum.
 - 4. Sealant shall have a VOC content of 420 g/L or less.
- E. ASJ Flashing Sealants and PVDC and PVC Jacket Flashing Sealants:
 - 1. Fire- and water-resistant, flexible, elastomeric sealant.
 - 2. Service Temperature Range: Minus 40 to plus 250 deg F
 - 3. Color: White.
 - 4. Sealant shall have a VOC content of 420 g/L or less.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with all foreign material removed. This includes but is not limited to water, oil, dirt, scale and rust.
- D. Only insulation and finish materials including adhesive cements and mastic which conform to the requirements of all-governing codes and ordinances shall be used.

3.2 INSTALLATION

- A. Division 1 – Quality Control: Install materials in accordance with manufacturer's instructions and the best practice of the trade.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulation on all piping shall be vapor sealed. On insulated piping with vapor barrier, insulate all fittings, valves, unions, flanges, strainers, flexible connections, and expansion joints. Vapor seal all exposed edges with jacket material and vapor barrier type adhesive.

- D. Repair or replace any existing insulation and surface finish disturbed or damaged by installation of new work using materials to match existing.
- E. Apply insulation to completely cover metal surface. Surface shall be applied to present a tight, smooth appearance.
- F. Exposed Piping: Locate insulation and cover seams in least visible locations.
- G. For water piping conveying fluids 140 degrees F or less, and on insulated piping without vapor barrier, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- H. For water piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- I. Neatly finish insulation at supports, protrusions, and interruptions.
- J. Do not use staples on vapor barrier insulation.
- K. Jackets:
 - 1. Indoor, Concealed Applications: Insulated pipes conveying fluids above ambient temperature shall have standard jackets, with vapor barrier, factory-applied or field-applied. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets may be used.
 - 2. Indoor, Concealed Applications: Insulated dual-temperature pipes or pipes conveying fluids below ambient temperature shall have vapor barrier jackets, factory-applied. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe, and finish with glass cloth and vapor barrier adhesive.
 - 3. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate and jacket as for concealed applications, and finish with PVC jackets.
 - 4. Outdoor Applications: Cover with .016" aluminum jacket with 2" overlap at seams and joints. Lay joints downward to shed water. Secure with 3/8" seals and straps at joints and aluminum bands on 8" centers between joints. Or cover ASJ vapor barrier jacket - Cover factory interior jacket with Alumaguard 60 .06" foil faced rubberized bitumen membrane.
- L. Inserts and Shields:
 - 1. Application: All insulated Piping 2 inches diameter or larger shall be installed with inserts and shields as follows.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Insert configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.

5. Insert material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- M. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions.
- N. Underground applications:
The internal pipe shall be hydrostatically tested to 150 psig or 1½ times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field applied insulation shall be placed only in straight sections. Field insulation of fittings shall not be acceptable. The mold for the polyurethane shall be made of clear adhesive backed polyester film. The installer shall seal the field joint area with a heat shrinkable adhesive backed wrap or with wrappings of glass reinforcement fully saturated with a catalyzed resin identical in properties to the factory-applied resin. Backfilling shall not begin until the heat shrink wrap has cooled or until the FRP lay-up has cured. All insulation and coating materials for making the field joint shall be furnished by the piping system manufacture.

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 (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 7 Section "Through-Penetration Firestop Systems" 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 7 Section "Through-Penetration Firestop Systems."

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.
10. Valve, gauge, test port insulation covers shall not be loose but shall provide an air/watertight seal.
11. 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. Valve, gauge, test port insulation covers shall not be loose but shall provide an air/watertight seal.

C. Install removable insulation covers only 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.

3.5 INSULATION SCHEDULE

Refer to the insulation schedule below for pipe insulation thickness by system. Not all systems are necessarily included in this project.

INSULATION SCHEDULE							
SERVICE	INSULATION	TEMPERATURE	NOMINAL PIPE SIZE				
	TYPE	RANGE (F°)	<1"	1" to < 1 1/2"	1 1/2" to < 4"	4" to < 8"	≥ 8"
Hot Water (HW)	A		INSULATION THICKNESS				
		> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	1 1/2	1 1/2	2	2	2
		105°-140°	1	1	1 1/2	1 1/2	1 1/2
Buried (HW)	C	> 350°	4 1/2	5	5	5	5
		251°-350°	3	4	4	4 1/2	4 1/2
		201°-250°	2 1/2	2 1/2	2 1/2	3	3
		141°-200°	2	2	2 1/2	2 1/2	2 1/2
		105°-140°	1 1/2	1 1/2	2	2	2
Chilled Water (CHW)	A	40° - 60°	1/2	1/2	1	1	1
		< 40°	1/2	1	1	1	1
Buried (CHW)	C	40° - 60°	1	1 1/2	1 1/2	1 1/2	1 1/2
		< 40°	1	1 1/2	1 1/2	1 1/2	1 1/2
Steam & Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Steam Condensate	A	Low Pressure	2 1/2	2 1/2	2 1/2	3	3
Condensate Drains	A	All	1/2	1/2	1	1	1
Cold Water Make up	A	All	1/2	1/2	1	1	1
Refrigerant Hot Gas	C	All	1 1/2	1 1/2	2	2	2
Humidifier Steam	A	All	2 1/2	2 1/2	2 1/2	3	3
Refrigerant Suction	C	All	1/2	1/2	1	1	1

END OF SECTION

SECTION 23 09 01

DIRECT DIGITAL CONTROL EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. The work of this Section consists of providing of all materials, labor, and equipment and the like necessary and/or required for the complete execution of all mechanical for this project, as required by the contract documents.

1.2 Qualifications of Bidder

- A. All bidders must be building automation contractors in the business of installing direct digital control building automation systems for a minimum of 5 years.
- B. All bidders must have a service and installation office in the Westchester area.
- C. All bidders must be authorized distributors or branch offices of the manufacturers specified.
- D. All bidders must have a trained staff of application engineers, who have been certified by the manufacturer in the configuration, programming, and service of the automation system.
- E. Manufacturers: Subject to compliance with requirements, provide products by the following manufactures.
 - 1. Johnson Controls.
 - 2. Andover Controls Corporation.
 - 3. Automated Logic Corporation.
 - 4. Reliable Controls.

1.3 Scope of Work

- A. Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, software, sensors, transducers, relays, valves, dampers, valve and damper operators, control panels, and other accessory equipment, along with a complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system. Unless otherwise specified, provide operators for equipment such as dampers and valves if the equipment manufacturer does not provide these. Coordinate requirements with the mechanical contractors.
- B. The Building Automation System (BAS) contractor shall review and study all HVAC drawings and the entire specification to familiarize himself with the equipment and system operation, and to verify the quantities and types of dampers, operators, alarms, controllers etc. to be provided.

- C. All interlocking, wiring and installation of control devices associated with the equipment listed below shall be provided under this Contract. When the BAS system is fully installed and operational, the BAS Contractor and representatives of the Owner will review and check out the system. At that time, the BAS contractor shall demonstrate the operation of the system and prove that it complies with the intent of the drawings and specifications.
- D. The Contractor shall furnish and install a complete building automation system including all necessary hardware, network wiring, all operating applications software, and all programming necessary to perform the control sequences of operation as called for in the specifications. The scope of work shall include control over, and graphic representation all new mechanical and plumbing equipment installed as part of this project. At a minimum, provide controls for the following:
 - 1. Air handling units
 - 2. Split system air handling units
 - 3. All coils and control valves
 - 4. Toilet, general exhaust, return, fan controls
 - 5. Geothermal Loop Primary pumps
 - 6. Dual Temperature water pumps primary and secondary
 - 7. Condensate pumps
 - 8. Frequency controllers, HOA's and starters
 - 9. Cabinet and unit's heater and convector control valves.
 - 10. Supplemental AC systems
 - 11. Power wiring to DDC devices and BAS panels.
- E. Provide services and manpower necessary for commissioning of system in coordination with the HVAC Contractor, Balancing Contractor and Owner's representative.
- F. All work performed under this section of the specifications will comply with all codes, laws, and governing bodies. If this specification and associated drawings exceed governing code requirements, the specification will govern. The Contractor shall obtain and pay for all necessary construction permits and licenses.
- G. Provide all labor and materials to perform all programming necessary at the School's new operator workstation to be located as directed by the School and to graphically represent and control EACH AND EVERY PIECE OF EQUIPMENT IN THE LISTS ABOVE. This shall include, all input and output status points, and functional points.

1.4 System Description

- A. The Building Automation System (BAS) shall consist of PC-based workstation and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of 10%, both input/output points and processing/control functions without having to add hardware, software, or controllers. For this project, the system shall consist of the following components:

B. Operator Workstations.

1. The BAS Contractor shall furnish (1) Operator Workstation Computer and (1) printer as described in Part 2 of the specification. This workstation must be running the standard workstation software developed and tested by the manufacturer of the network controllers and the standalone controllers. No third-party front-end workstation software will be acceptable. Provide all necessary software and licensing as required.

C. Ethernet-based Network Controllers.

1. The BAS Contractor shall furnish Ethernet-based network controllers as described in Part 2 of the specification. These controllers will connect directly to the Operator Workstation over Ethernet, provide communication to the Standalone Digital Control Units and/or other Input/Output Modules and serve as a gateway to equipment furnished by others (if applicable).

D. Standalone Digital Control Units (SDCUs).

1. Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, control, and terminal unit control. Each SDCU will operate completely standalone, containing all the I/O and programs to control its associated equipment.

1.5 Work by Others

- A. The BAS Contractor shall coordinate with other trade contractors performing work on this project necessary to achieve a complete installation. To that end, the contractor shall consult the drawings and specifications for all other trades to determine the nature and extent of work by others.
- B. The BAS Contractor shall furnish all control valves, sensor wells, flow meters and other similar equipment for installation by the Mechanical Contractor.
- C. The BAS Contractor shall provide field supervision to the designated contractor for the installation of the following as required:
 1. Automatic control dampers
 2. Fire/smoke dampers
- D. The Electrical Contractor shall provide:
 1. All power wiring to motors, heat trace, junction boxes for power to BAS panels.
 2. Furnish smoke detectors and wire to the building fire alarm system. HVAC Contractor to mount devices. BAS Contractor to hardwire to fan shut down. BAS contractor to coordinate this with the electrical contractor.

1.6 Code Compliance

- A. Provide BAS components and ancillary equipment, which are UL-916 listed and labeled.
- B. All equipment or piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.
- C. All wiring shall conform to the National Electrical Code.
- D. All smoke dampers shall be rated in accordance with UL 555S.
- E. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
- F. Comply with FCC, Part 68 rules for telephone modems and data sets.

1.7 Submittals

- A. All shop drawings shall be prepared in AutoCAD software. In addition to the drawings, the Contractor shall furnish a diskette containing the identical information. Drawings shall be B size or larger.
- B. Shop drawings shall include a riser diagram depicting locations of all controllers and workstations, with associated network wiring. Also included shall be individual schematics of each mechanical system showing all connected points with reference to their associated controller. Typical will be allowed where appropriate.
- C. Submittal data shall contain manufacturer's data on all hardware and software products required by the specification. Valve, damper, and air flow station schedules shall indicate size, configuration, capacity, and location of all equipment.
- D. Software submittals shall contain narrative descriptions of sequences of operation, program listings, point lists, and a complete description of the graphics, reports, alarms, and configuration to be furnished with the workstation software. Information shall be bound or in a three-ring binder with an index and tabs. All literature, descriptions, equipment spec sheets, sequences etc shall be on 8 1/2 x 11 or larger sized sheets. All details diagrams and schematics shall be on 11X17 sized sheets or larger.
- E. Submit five (5) copies of submittal data and shop drawings to the Engineer for review prior to ordering or fabrication of the equipment. The Contractor prior to submitting shall check all documents for accuracy.
- F. The Engineer will make corrections, if required, and return to the Contractor. The Contractor will then resubmit with the corrected or additional data. This procedure shall be repeated until all corrections are made to the satisfaction of the Engineer and the submittals are fully approved.

- G. Submit a training class syllabus and training manual for review with the temperature controls submittal. The training manual shall be custom made for this project. Manufactures brochures, and installation manuals will not be acceptable for this purpose. Submit a type of written overview and a written summary of each topic to be covered. The document shall be suitable for a system operator to use as a quick reference guide to basic system operation as applicable for this project. Refer to section 1.9 paragraph B, for the minimum requirement of training to be included.

1.8 System Startup & Commissioning

- A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
- B. The BAS contractor shall commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives.
- C. The BAS Contractor shall provide all manpower and engineering services required to assist the HVAC Contractor and Balancing Contractor in testing, adjusting, and balancing all systems in the building. The BAS Contractor shall have a trained technician available on request during the balancing of the systems. The BAS Contractor shall coordinate all requirements to provide a complete air balance with the Balancing Contractor and shall include all labor and materials in his contract.

1.9 Training

- A. The BAS Contractor shall provide both on-site training to the Owner's representative and maintenance personnel per the following description:
- B. On-site training shall consist of a minimum of (3) separate 4-hour sessions of hands-on instruction geared at the operation and maintenance of the systems. The sessions shall be scheduled at the beginning of substantial completion and spaced out over the first year of owner use. The first session curriculum shall include:
 - 1. System Overview
 - 2. System Software and Operation
 - a. System access
 - b. Software features overview
 - c. Changing set-points and other attributes
 - d. Scheduling
 - e. Editing programmed variables
 - f. Displaying color graphics
 - g. Setting up reports
 - h. Running reports
 - i. Workstation maintenance
 - j. Application programming

3. Operational sequences including start-up, shutdown, adjusting and changing system variables. These items shall be reviewed for all equipment installed under this project and or connected to the BMS under this project.
4. Equipment and hardware overview and maintenance. This shall include:
 - a. Review of all hardware installed under this project.
 - b. Review of a system schematic.
 - c. Review of where each controller is in the building and what its function is. This shall include a walking, hands-on tour, and demonstration of every controller.

1.10 Operating and Maintenance Manuals

- A. The operation and maintenance manuals shall contain all information necessary for the operation, maintenance, replacement, installation, and parts procurement for the entire BAS. This documentation shall include specific part numbers and software versions and dates. A complete list of recommended spare parts shall be included with the lead-time and expected frequency of use of each part clearly identified.
- B. Following project completion and testing, the BAS contractor will submit as-built drawings reflecting the exact installation of the system. The as-built documentation shall also include a copy of all application software both in written form and on diskette.

1.11 Warranty

- A. The BAS contractor shall warranty the system for 12 months after system acceptance and beneficial use by the owner. During the warranty period, the BAS contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the Sequence of Operation section of the specification.
- B. Updates to the manufacturer's software shall be provided at no charge during the warranty period.

1.12 Programming

- A. Sequence of operations: The controls contractor shall review the sequences of operation given in section 23 09 93 of this specification. "Canned", preprogrammed, or typical sequences by the manufacture may not be acceptable and shall only be used if accepted by the engineer. Otherwise, the controls contractor shall be capable of and responsible for providing custom programming, hardware, software, and labor as required to achieve the sequences of operation as specified.

1.13 System Architecture

- A. General
- B. The Building Automation System (BAS) shall consist of all new Network Control Units (NCUs), a family of Standalone Digital Control Units (SDCUs), Input/Output Unit Modules (IOU Modules), Operator Workstations (OWs), and one File Server to support system configurations where more than one operator workstation is required. The BAS shall provide control, alarm detection, scheduling, reporting and information management for the entire classroom building and all new and existing equipment in the

building, and Wide Area Network (WAN) if applicable, from a single ODBC-compliant database.

C. Level 1 Network Description

1. Level 1, the main backbone of the system, shall be an Ethernet LAN/WAN. Network Control Units, Operator Workstations, and the Central File Server shall connect directly to this network without the need for Gateway devices. The contractor shall visit the site and review the existing Andover temperature controls equipment installed in the building and in the physical plant. Certain of these controllers may be suitable for reuse. The network shall be an extension of the existing in the building as required to achieve a complete system,

D. Level 2 Network Description

1. Level 2 of the system shall consist of one or more field buses managed by the Network Control Units. The Level 2 field buses may consist of one or both of the following types:
2. An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or
3. An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules.
4. These IOU modules may be mounted within the NCU enclosure or remotely mounted via a single, twisted, shielded pair of wires.
5. The BAS shall be capable of being segmented, through software, into multiple local area networks (LANs) distributed over a wide area network (WAN), sharing a single file server. This enables workstations to manage a single LAN (or building), and/or the entire system with all devices being assured of being updated by and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database – with no need for a separate file server.

E. Standard Network Support

1. All NCUs, Workstation(s) and File Server shall be capable of residing directly on the owner's Ethernet TCP/IP LAN/WAN with no required gateways. Furthermore, the NCU's, Workstation(s) and File Server shall be capable of using standard, commercially available, off-the-shelf Ethernet infrastructure components such as routers, switches, and hubs. With this design the owner may utilize the investment of an existing or new enterprise network or structured cabling system. This also allows the option of the maintenance of the LAN/WAN to be performed by the owner's Information Systems Department as all devices utilize standard TCP/IP components.

F. Remote Communications

1. In addition to the above LAN/WAN architecture support, the same workstation software (front end) must be capable of managing remote systems via standard dial-up phone lines as a standard component of the software. Front-end "add-on" software modules to perform remote site communication shall not be acceptable.
2. The remote system architecture shall consist of two levels providing control, alarm detection, reporting and information management for the remote facility. Level 1 shall contain the Remote Site Control Unit, communicating to the remotely located, Operator Workstation(s) using a modem and a standard dial-up

phone line. Level 2 shall consist of one or more field buses controlled by the RSCU. The field buses may consist of one or both of two types:

3. 1) An RS485, token passing bus that supports up to 127 Standalone Digital Control Units (SDCUs) for operation of HVAC equipment and lighting, or
4. 2) An RS485 field bus that supports up to 32 devices from a family of plug-in, IOU modules that may be mounted within the RSCU enclosure or remotely mounted on a single, twisted, shielded pair of wires.

G. System Expansion

1. The BAS system shall be scalable and expandable at all levels of the system using the same software interface, and the same Level 1 and Level 2 controllers. Systems that require replacement of either the workstation software or field controllers to expand the system shall not be acceptable.
2. The BAS shall be expandable to include Security and Access Control functions at any time in the future with no additional workstations, front-end software or Level 1 controllers required. Standalone Digital Control Units or IOU modules shall be able to be added to the existing Level 1 controller's field bus(es), to perform security and card access applications. In this way, an owner's existing investment in wiring infrastructure may be leveraged and the cost and inconvenience of adding new field bus wiring will be minimized.
3. Additionally, an integrated video badging option must be able to be included with no additional workstations required. This photo ID option must share the same database as the BAS to eliminate the need for updating multiple databases.
4. The system shall use the same application programming language for all levels: Operator Workstation, Network Control Unit, Remote Site Control Unit and Standalone Digital Control Unit. Furthermore, this single programming language shall be used for all applications: environmental control, card access control, intrusion detection and security, lighting control, leak detection / underground storage tank monitoring, and digital data communication interfaces to third party microprocessor-based devices.

H. Support for Open Systems Protocols

The BAS design must include solutions for the integration of the following "open systems" protocols: BACnet, LonTalk™, and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFDs).

- I. The system shall also provide the ability to program custom ASCII communication drivers, that will reside in the NCU, for communication to third party systems and devices. These drivers will provide real time monitoring and control of the third-party systems.

1.14 Network Control Units (NCUs)

- A. Network Control Units shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each NCU control panel shall consist of modular hardware including power supply, CPU board, and input/output modules. Enough NCUs shall be supplied to fully meet the requirements of this specification and the attached point list. NCUs for telephone dialup sites shall be of the same design as the Ethernet control units but without the plug-in Ethernet network interface card (NIC), i.e., NCUs,

which include a NIC, shall be interchangeable whether used on a LAN/WAN or a dialup site.

B. Webserver Functionality

All NCUs on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a Web Server. The NCU shall have the ability to store HTML code and “serve” pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer™, Netscape Navigator™, etc.) to access real-time data from the entire BAS via any NCUs.

Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.

The WEB server interface shall be capable of password security, including validation of the requesting PC’s IP address. The WEB server interface shall allow the sharing of data or information between any controller, or process or network interface (BACnet, LonTalk and TCP/IP) that the BMS has knowledge of, regardless of where the point is connected on the BAS network or where it is acquired from.

The BAS network controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e., WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored on any shared network device. The BAS WEB server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the BAS WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications

1. Memory:

A minimum of 64MB of RAM shall be provided for NCUs with expansion up to 128 MB. The 64 MB versions shall include a floating-point math co-processor.

2. Communication Ports:

Each NCU shall provide communication to both the Workstation(s) and the field buses. In addition, each NCU must have at least 3 other communications ports that support a telephone modem, portable service tool, serial printer, and connection to third party controllers such as a chiller control panel. On a LAN/WAN system the NCU shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).

3. Input/Output (I/O):

Each NCU shall support the addition of the following types of inputs and outputs:

- Digital Inputs for status/alarm contacts
- Counter Inputs for summing pulses from meters.

- Thermistor inputs for measuring temperatures in space, ducts and thermowells.
 - Analog inputs for pressure, humidity, flow and position measurements.
 - Digital Outputs for on/off equipment control.
 - Analog Outputs for valve and damper position control, and capacity control of primary equipment including all air handler and fan coil control valves.
4. Modular Expandability:

The system shall employ a modular I/O design to allow easy expansion. Input and output capacity are to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.
 5. Hardware Override Switches:

All digital output units shall include three position manual override switches to allow selection of the ON, OFF, or AUTO output state. These switches shall be built into the unit and shall provide feedback to the controller so that the position of the override switch can be obtained through software. In addition, each analog output shall be equipped with an override potentiometer to allow manual adjustment of the analog output signal over its full range, when the 3-position manual override switch is placed in the ON position.
 6. Local Status Indicator Lamps:

Provide as a minimum LED indication of CPU status, Ethernet LAN status, and field bus status. For each output, provide LED indication of the value of the output (On/Off). For each output module provide an LED which gives a visual indication of whether any outputs on the module are manually overridden.
 7. Real Time Clock (RTC):

Each NCU shall include a battery-backed, real time clock, accurate to 10 seconds per day. The RTC shall provide the following: time of day, day, month, year, and day of week. In normal operation the system clock will be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years and be Year 2000 compliant.
 8. Power Supply:

The power supply for the NCUs shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of +/- 20%. Line voltage below the operating range of the system shall be considered outages. The controller shall contain over voltage surge protection and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (-48 VDC).
 9. Automatic Restart After Power Failure:

Upon restoration of power after an outage, the ECU shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.
 10. Battery backup:

Each NCU with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of

battery backup to maintain all volatile memory or, a minimum of 2 hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe (such as 1 hour) of running on full UPS, the unit will shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software Specifications

1. General.

The NCU shall contain flash ROM as the resident operating system. Application software will be RAM resident. Application software will only be limited by the amount of RAM memory. There will be no restrictions placed on the type of application programs in the system. Each NCU shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage, etc.

2. User Programming Language:

The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The NCU shall have the ability to perform the following pre-tested control algorithms:

- a. Proportional, Integral plus Derivative Control (PID)
- b. Self Tuning PID
- c. Two Position Control
- d. Digital Filter
- e. Ratio Calculator
- f. Equipment Cycling Protection

2. Mathematical Functions:

- a. Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These must be able to be used in the

same equations with the mathematical operators and nested up to five parentheses deep.

3. Energy Management Applications:
 - a. NCUs shall have the ability to perform any or all of the following energy management routines:
 - b. Time of Day Scheduling
 - c. Calendar Based Scheduling
 - d. Holiday Scheduling
 - e. Temporary Schedule Overrides
 - f. Optimal Start
 - g. Optimal Stop
 - h. Night Setback Control
 - i. Enthalpy Switchover (Economizer)
 - j. Peak Demand Limiting
 - k. Temperature Compensated Duty Cycling
 - l. CFM Tracking
 - m. Heating/Cooling Interlock
 - n. Free Cooling
 - o. Hot Water Reset
 - p. Chilled Water / HW water Reset
 - q. Chiller / boiler Sequencing
4. History Logging:
 - a. Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 32767 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.
5. Alarm Management:
 - a. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the NCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device. Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the Operator Workstation is temporarily interrupted, the alarm will be buffered in the NCU. When communications return, the alarm will be transmitted to the Operator Workstation if the point is still in the alarm condition.
6. Reporting.

- a. The NCU shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

1.15 Standalone Digital Control Units (SDCUs)

A. General:

1. Standalone Digital Control Units shall provide control of HVAC and lighting. Each controller shall have its own control programs and will continue to operate in the event of a failure or communication loss to its associated NCU.

B. Memory:

1. Control programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Communication Ports:

1. SDCUs shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the NCU online. It shall be possible from a service port on any SDCU to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any NCU or any SDCU on a different field bus.

D. Input/Output:

1. Each SDCU shall support the addition of the following types of inputs and outputs:
 - a. Digital Inputs for status/alarm contacts
 - b. Counter Inputs for summing pulses from meters.
 - c. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
 - d. Analog inputs for pressure, humidity, flow and position measurements.
 - e. Digital Outputs for on/off equipment control.
 - f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

E. Expandability:

1. Input and output capacity shall be expandable using plug-in modules. A minimum of two modules shall be added to the base SDCU before additional power is required.

F. Networking:

1. Each SDCU will be able to exchange information on a peer-to-peer basis with other Standalone Digital Control Units during each field bus scan. Each SDCU shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each SDCU shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to an NCU.

G. Indicator Lamps:

1. SDCUs will have as a minimum, LED indication of CPU status, and field bus status.

H. Real Time Clock (RTC):

1. An SDCU shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The RTC shall provide the following information: time of day, day, month, year, and day of week. Each SDCU shall receive a signal, every hour, over the network from the NCU which synchronizes all SDCU real time clocks.

I. Automatic Restart After Power Failure:

1. Upon restoration of power, the SDCU shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

J. Battery Back Up:

1. Each SDCU shall have at least 3 years of battery back up to maintain all volatile memory.

K. Alarm Management:

1. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms will be tested each scan of the SDCU and can result in the display of one or more alarm messages or reports. Up to 8 alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered. Alarm messages can be sent to a local terminal or modem connected to an NCU or to the Operator's Workstation(s). Alarms will be generated based on their priority. A minimum of 255 priority levels shall be provided. If communication with the NCU is temporarily interrupted, the alarm will be buffered in the SDCU. When communications return, the alarm will be transmitted to the NCU if the point is still in the alarm condition.

L. Air Handler Controllers

1. AHU Controllers shall be capable of meeting the requirements of the sequence of operation found in the Execution portion of this specification and for future expansion.

2. AHU Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
3. AHU Controllers shall be fully user programmable to allow for modification of the application software.
4. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.
5. A manual override switch shall be provided for all digital and analog outputs on the AHU Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

M. VAV Terminal Unit Controllers (Not Used)

1. VAV Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of VAV boxes to address current requirements as described in the Execution portion of this specification, and for future expansion:
 - a. Single Duct Cooling Only
 - b. Single Duct Cooling with Reheat (Electric or Hot Water)
 - c. Fan Powered (Parallel or Series)
 - d. Dual Duct (Constant or Variable Volume)
 - e. Supply/Exhaust
2. VAV Controllers for single duct applications will come equipped with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb. and contain an override mechanism for manual positioning of the damper during startup and service. VAV Controllers shall contain an integral velocity sensor accurate to +/- 5% of the full range of the box's CFM rating. Each controller shall perform the sequence of operation described in Part 3 of this specification and have the capability for time-of-day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending. VAV Controllers shall be able to communicate with any other Standalone Digital Control Unit on the same field bus with or without communication to the NCU managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 VAV controllers per field bus.
3. Unitary Controllers
 - a. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:
 - 1) Cabinet heater and convectors
 - 2) Rooftop top air handling units
 - 3) Fan Coils
 - 4) Unit and cabinet heaters
 - b. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the

capability for time-of-day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

N. Lighting Controllers (Not Used)

1. Lighting controllers shall provide direct control of 20 Amp, 277 VAC lighting circuits using mechanically held, latching relays. Controllers will contain from 8 to 48 circuits per enclosure. Each controller shall also contain inputs for direct connection to light switches and motion detectors. Each controller shall have the capability for time-of-day scheduling, occupancy mode control, after hour operation, alarming, and trending.

O. Display Controllers

1. Display controllers are standalone, touch screen-based operator interfaces. The controller shall be designed for flush mounting in a finished space, with a minimum display size of 9 x 9 inches. Software shall be user programmable allowing for custom graphical images that simulate floor plans, menus, equipment schematics along with associated real time point values coming from any NCU on the network. The touch screen display shall contain a minimum of 64 possible touch cells that permit user interaction for changing screens, modifying set-points or operating equipment. Systems that do not offer a display controller as specified must provide a panel mounted computer with touch screen capability as an alternative. All air handling units shall use display controllers.

1.16 Operator Workstation Requirements

A. General.

The BAS workstation software shall be configurable as a multi-workstation system where the database is located on a central file server in the physical plant. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 10MBPS or 100MBPS. All Workstations shall be Pentium II based personal computers operating under the Microsoft NT operating system. The application software shall be capable of communication to all Network Control Units and Standalone Digital Control Units, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

For multi-workstation systems, a minimum of 256 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one workstation will automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will not be acceptable.

B. Workstation Requirements

The workstation shall consist of the following:

3.6 GHz Intel Core i7 processor with 64GB of RAM

Microsoft Windows operating system (latest version compatible with BMS software)

Serial port, parallel port

10/100MBPS Ethernet NIC
500 GB hard disk
CD-ROM drive
High resolution (minimum 1080 x 1920), 17" flat panel display
Mouse
Full function keyboard
Audio sound card and speakers
License agreement for all applicable software.

C. File Server Hardware Requirements.

The file server computer shall contain of the following:
3.6 GHz Intel Core 2 Duo processor with 64GB of RAM
Microsoft Windows operating system (latest version compatible with BMS software)
10/100MBPS Ethernet NIC
500 GB hard disk
CD-ROM drive
Mouse
Full function keyboard
License agreement for all applicable software.
Provide one Windows 2000-compatible 56 Kbaud modem.

D. Printer

Provide a Printer. Printer shall be a HP LaserJet.

E. Monitor:

1. The monitor shall be flat screen minimum of 17", LED type, 1920x1080 resolution, 16:9 aspect ratio, VGA.

F. Workstation Software

1. General Description

The software architecture must be object-oriented in design, a true 32-bit application suite utilizing Microsoft's OLE, COM, DCOM and ODBC technologies. These technologies make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the wealth of data available from the BAS.

The workstation functions shall include monitoring and programming of all DDC controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.

Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information will be available in graphic or text displays. Graphic displays will feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location

of information throughout the DDC system. All operator functions shall be selectable through a mouse.

2. System Database

The files server database engine must be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity)-compliant database engine allows for an owner to utilize “their” choice of database and due to its “open” architecture, allows an owner to write custom applications and/or reports which communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database will contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

3. User Interface

The BAS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of “hot-spots” that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface must be able to be configured to become a user’s “PC Desktop” – with all the links that a user needs to run other applications. This, along with the Windows 10 user security capabilities, will enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BAS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

4. User Security

The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall range from View only, acknowledge alarms, Enable/disable, and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to every class of object in the system. The system must allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. Configuration Interface

The workstation software shall use a familiar Windows Explorer™-style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a “network map” of all controllers and their associated points, programs, graphics, alarms, and reports in an easy-to-understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system. This allows consistency in point naming. For example, each fan coil unit controller can have an input called Space Temperature and a setpoint called CFM Setpoint.

The FCU controller name shall be unique such as FCU for LAB101. Systems requiring unique object names throughout the system will not be acceptable.

The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BAS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BAS.

6. Color Graphic Displays

The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic using the mouse. Requirements of the color graphic subsystem include:

- a. SVGA, bit-mapped displays. The user shall have the ability to import AutoCAD generated picture files as background displays.
- b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs which can be "dropped" on a graphic through the use of a software configuration "wizard". These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.
- c. Status changes or alarm conditions must be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.
- d. Graphic panel objects shall be able to be configured with multiple "tabbed" pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.
- e. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators must be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.
- f. Automatic monitoring

The software shall allow for the automatic collection of data and reports from any controller through either a hardwire or modem communication link. The frequency of data collection shall be completely user configurable.

g. Alarm Management

The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and

comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) will be integrated into the overall alarm management system and will appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports.

Alarm management features shall include:

- 1) A minimum of 255 alarm notification levels. Each notification level will establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.
- 2) Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username, and time of alarm silence (soft acknowledgement)
- 3) Automatic printing of the alarm information or alarm report to an alarm printer or report printer.
- 4) Playing an audible beep or audio (wav) file on alarm initiation or return to normal.
- 5) Sending an email or alphanumeric page to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and alphanumeric paging of alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required.
- 6) Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temp alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.
- 7) An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.
- 8) The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.
- 9) The active alarm viewer can be configured such that an operator must type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

h. Custom Report Generation

The software will contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the

report is displayed, it will automatically spawn the associated report editor such as MS Word™.

- 1) Reports can be of any length and contain any point attributes from any controller on the network.
- 2) The report generator will have access to the user programming language to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.
- 3) It shall be possible to run other executable programs whenever a report is initiated.
- 4) Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.
- 5) Standard reports shall include:
 - a) Points in each controller.
 - b) Points in alarm
 - c) Disabled points
 - d) Overridden points
 - e) Operator activity report
 - f) Alarm history log.
 - g) Program listing by controller with status.
 - h) Network status of each controller

i. Spreadsheet-style reports

The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data and highlight data which meets user-defined criteria.

j. HTML Reporting

The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature will create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which will allow those users with access to the directory to "point" their web browser at the file and view the report.

k. Scheduling- It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.

- 1) Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.

- 2) Each schedule will appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.
- 3) Schedules will be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation will be automatically updated to the corresponding schedule in the controller.

I. Programmer's Environment

The programmer's environment will include access to a superset of the same programming language supported in the controllers. Here the programmer will be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dockable debug and watch bars for program debugging and viewing updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.

m. Saving/Reloading

The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller – it must also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

n. Data Logging

The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simple menu selection. This data shall be able to be saved to file and/or printed.

o. Audit Trail

The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

p. Fault Tolerant File Server Operation

The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions.

The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the

Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.

When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

1.17 Portable Operator's Terminal

- A. Provide one 15" full screen, laptop portable operator terminal shall communicate directly to all controllers. The laptop software shall enable users to monitor both instantaneous and historical point data, modify control parameters, and enable/disable any point or program in any controller on the network.
1. The laptop computer will be a Intel Core 2 Duo-based portable computer with a minimum of 4GB of RAM memory, and a 160GB hard disk drive, running Windows ver 7 or Windows XP.
 2. The laptop service tool will connect to any Ethernet controller or standalone controller via a dedicated service port. From this single connection, the user shall be able to communicate with any other controller on the LAN.
 3. The laptop service tool will limit operator access by passwords. The service tool must support, at a minimum, the following password-protected user types: Administrator, Modify Parameters, View Only.
 4. The laptop software shall include built-in menus for viewing points by controller, enabling, disabling, and viewing programs, configuring controllers, and communicating to other controllers on the network.

1.18 DDC Sensors and Point Hardware

A. Temperature Sensors

1. All temperature devices shall use precision thermistors accurate to +/- 1 degree F over a range of -30 to 230 degrees F. Space temperature sensors shall be accurate to +/- .5 degrees F over a range of 40 to 100 degrees F.
2. Space sensors shall be having off white enclosure and shall be mounted on a standard electrical box. Space sensors shall use surface mounted finished cast electrical box for surface mounting with metal "wire-mold" to conceal wiring for all solid masonry partitions. For space sensors located on gypsum board partitions,

wiring shall be concealed inside the walls with recessed flush mounted electrical boxes. In general, control wiring shall run from the ceiling plenum to the box which shall be wall mounted next to the door or as shown on plan.

3. The space temperature sensor housing shall utilize buttons for adjusting the space temperature set-point, as well as a push button for selecting after hours operation, fan speed and all and other operator selectable parameters. Operators shall be able to adjust set points directly from the sensor. All space sensors, (located in public location, office, classrooms), shall incorporate either an LED or LCD display for viewing the space temperature, set point and other operator selectable parameters. Space sensors located in storerooms, MER, and unoccupied space are not required have LED or LCD display.
4. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless-steel tube. Probe style duct sensors are useable in air handling applications where the coil or duct area is less than 14 square feet.
5. Averaging sensors shall be employed in ducts which are larger than 14 square feet. The averaging sensor tube must contain at least one thermistor for every 3 feet, with a minimum tube length of 12 feet.
6. Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications.
7. A pneumatic signal shall not be allowed for sensing temperature.

B. Humidity Sensors

1. Humidity devices shall be accurate to +/- 5% at full scale for space and +/- 3% for duct and outside air applications. Suppliers shall be able to demonstrate that accuracy is NIST traceable.
2. Provide a handheld field calibration tool that both reads the output of the sensor and contains a reference sensor for ongoing calibration.

C. Pressure Sensors

1. Air pressure measurements in the range of 0 to 10" water column will be accurate to +/- 1% using a solid-state sensing element. Acceptable manufacturers include Modus Instruments and Mamac.
2. Differential pressure measurements of liquids or gases shall be accurate to +/- 0.5% of range. The housing shall be Nema 4 rated.

D. Current and KW Sensors

1. Current status switches shall be used to monitor fans, pumps, motors and electrical loads. Current switches shall be available in solid and split core models and offer either a digital or an analog signal to the automation system. Acceptable manufacturer is Veris or approved equal.
2. Measurement of three phase power shall be accomplished with a kW/kWH transducer. This device shall utilize direct current transformer inputs to calculate

the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWH). Provide Veris Model 6000 Power Transducer or approved equal.

E. Flow Sensors

1. Provide an insertion vortex flowmeter for measurement of liquid, gas or steam flows in pipe sizes above 3 inches.
2. Install the flow meter on an isolation valve to permit removal without process shutdown.
3. Sensors shall be manufactured by EMCO or approved equal.

F. Electric/Pneumatic Transducers

1. Electric to pneumatic transducers shall operate from either a PWM or analog signal. E/P transducers shall be rated for 0 - 20 psi operation and accurate to 2% of full scale. E/P transducers shall have a maximum air consumption of 100 SCIM.
2. E/P transducers may be installed at the end device (damper or valve), or mounted separately in a field interface panel, or as part of the controller. All transducers will be calibrated. Panel mounted transducers shall be Sensycon or approved equal.

G. Electric/Pneumatic Solenoid Valves

Electric solenoid operated pneumatic valves (EP's) shall have a three-port operation: common, normally open, and normally closed. They shall be rated for 50 psig when used for 25 psig or less applications or rated for 150 psig when used for 100 psig or less applications. The coils shall be equipped with transient suppression devices to limit transients to 150 percent of the rated coil voltage.

1.19 Control Valves

- A. Provide automatic control valves suitable for the specified controlled media (steam, water, or glycol). Provide valves which mate and match the material of the connected piping. Equip control valves with the actuators of required input power type and control signal type to accurately position the flow control element and provide sufficient force to achieve required leakage specification.
- B. Control valves shall meet the heating and cooling loads specified, and close off against the differential pressure conditions within the application. Valves should be sized to operate accurately and with stability from 10 to 100% of the maximum design flow.
- C. Trim material shall be stainless steel for steam and high differential pressure applications.
- D. Electric actuation should be provided on all terminal unit reheat applications.

1.20 Dampers

- A. Automatic dampers furnished by the Building Automation Contractor shall be single or multiple blades as required. Dampers are to be installed by the HVAC Contractor under the supervision of the BAS Contractor. All blank-off plates and conversions necessary to install smaller than duct size dampers are the responsibility of the Sheet Metal Contractor.
- B. Damper frames are to be constructed of 13-gauge galvanized sheet steel mechanically joined with linkage concealed in the side channel to eliminate noise as friction. Compressible spring stainless steel side seals, and acetal or bronze bearings shall also be provided.
- C. Damper blade width shall not exceed eight inches. Seals and 3/8-inch square steel zinc plated pins are required. Blade rotation is to be parallel or opposed as shown on the schedules.
- D. For high performance applications, control dampers will meet or exceed the UL Class I leakage rating.
- E. Control and smoke dampers shall be Ruskin or approved equal.
- F. Provide opposed blade dampers for modulating applications and parallel blade for two position control.

1.21 Damper Actuators

- A. Electronic Actuators – the actuator shall be direct coupled over the shaft, enabling it to be mounted directly to the damper shaft without the need for connecting linkage. The actuator shall have electronic overload circuitry to prevent damage. For power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Non-spring return actuators shall have an external manual gear release to allow positioning of the damper when the actuator is not powered.
- B. Pneumatic Actuators - shall be of the synthetic elastomer diaphragm piston type and shall be fully proportioning unless otherwise specified. They shall have full metal bodies and utilize replaceable diaphragms. Damper actuators on large sections of modulating dampers (>25 sq.ft.) or high face velocity applications (such as fan inlet vanes) shall be equipped with pilot positioners to provide repeatability and quick response. Also provide pilot positioners on steam valves requiring 1/3 – 2/3 operation. (Not used)

1.22 Smoke Detectors

- A. Air duct smoke detectors shall be by Air Products & Controls or approved equal. The detectors shall operate at air velocities from 300 feet per minute to 4000 feet per minute.
- B. The smoke detector shall utilize a photoelectric detector head.
- C. The housing shall permit mechanical installation without removal of the detector cover.

- D. The detectors shall be listed by Underwriters Laboratories and meet the requirements of UL 268A.

1.23 Airflow Measuring Stations

- A. Provide a thermal anemometer using instrument grade self heated thermistor sensors with thermistor temperature sensors.
- B. The flow station shall operate over a range of 0 to 5,000 feet/min with an accuracy of +/- 2% over 500 feet/min and +/- 10 ft/min for reading less than 500 feet/min.
- C. The output signal shall be linear with field selectable ranges including 0-5 VDC, 0-10VDC and 4-20 mA.
- D. Furnish Ebtron Series 3000 airflow stations or approved equal.

PART 2 - EXECUTION

2.1 Contractor Responsibilities

A. General

Installation of the building automation system shall be performed by the Contractor or a subcontractor. However, all installation shall be under the personal supervision of the Contractor. The Contractor shall certify all work as proper and complete. Under no circumstances shall the design, scheduling, coordination, programming, training, and warranty requirements for the project be delegated to a subcontractor.

B. Access to Site

1. Unless notified otherwise, entrance to building is restricted. No one will be permitted to enter the building unless their names have been cleared with the Owner or the Owner's Representative.

C. Code Compliance

1. All wiring shall be installed in accordance with all applicable electrical codes and will comply with equipment manufacturer's recommendations.

D. Cleanup

1. At the completion of the work, all equipment pertinent to this contract shall be checked and thoroughly cleaned, and all other areas shall be cleaned around equipment provided under this contract.

2.2 Wiring, Conduit, and Cable

- A. All wire will be copper and meet the minimum wire size and insulation class listed below:

Wire Class	Wire Size	Isolation Class
Power	12 Gauge	600 Volt
Class One	14 Gauge Std.	600 Volt
Class Two	18 Gauge Std.	300 Volt
Class Three	18 Gauge Std.	300 Volt
Communications	Per Mfr.	Per Mfr.

- B. Power and Class One wiring may be run in the same conduit. Class Two and Three wiring and communications wiring may be run in the same conduit.
- C. Where different wiring classes terminate within the same enclosure, maintain clearances, and install barriers per the National Electric Code.
- D. Where wiring is required to be installed in conduit, EMT shall be used. Conduit shall be minimum 1/2-inch galvanized EMT. Set screw fittings are acceptable for dry interior locations. Watertight compression fittings shall be used for exterior locations and interior locations subject to moisture. Provide conduit seal off fitting where exterior conduits enter the building or between areas of high temperature/moisture differential.
- E. Flexible metallic conduit (max. 3 feet) shall be used for connections to motors, actuators, controllers, and sensors mounted on vibration producing equipment. Liquid-tight flexible conduit shall be use in exterior locations and interior locations subject to moisture.
- F. Junction boxes shall be provided at all cable splices, equipment termination, and transitions from EMT to flexible conduit. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers.
- G. Where the space above the ceiling is a supply or return air plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit.
- H. Coaxial cable shall conform to RG62 or RG59 rating. Provide plenum rated coaxial cable when running in return air plenums.
- I. Fiber optic cable shall include the following sizes: 50/125, 62.5/125 or 100/140.
- J. Only glass fiber is acceptable, no plastic.
- K. Fiber optic cable shall only be installed and terminated by an experienced contractor. The BAS contractor shall submit to the Engineer the name of the intended contractor of the fiber optic cable with his submittal documents.
- L. Hardware Installation

2.3 Installation Practices for Wiring

- A. All controllers are to be mounted vertically and per the manufacturer's installation documentation.
- B. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral, circuit will not feed any other circuit or device.

- C. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
- D. Wires are to be attached to the building proper at regular intervals such that wiring does not droop. Wires are not to be affixed to or supported by pipes, conduit, etc.
- E. Conduit in finished areas, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exception: metallic surface raceway may be used in finished areas on masonry walls. All surface raceway in finished areas must be color matched to the existing finish within the limitations of standard manufactured colors.
- F. Conduit, in non-finished areas where possible, will be concealed in ceiling cavity spaces, plenums, furred spaces, and wall construction. Exposed conduit will run parallel to or at right angles to the building structure.
- G. Wires are to be kept a minimum of three (3) inches from hot water, steam, or condensate piping.
- H. Where sensor wires leave the conduit system, they are to be protected by a plastic insert.
- I. Wire will not be allowed to run across telephone equipment areas.

2.4 Installation Practices for Field Devices

- A. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
- B. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100 percent of the stroke.
- C. Relay outputs will include transient suppression across all coils. Suppression devices shall limit transients to 150% of the rated coil voltage.
- D. Water line mounted sensors shall be removable without shutting down the system in which they are installed.
- E. For duct static pressure sensors, the high-pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low-pressure port shall be left open to the plenum area at the point that the high-pressure port is tapped into the ductwork.
- F. For building static pressure sensors, the high-pressure port shall be inserted into the space via a metal tube. Pipe the low-pressure port to the outside of the building.

2.5 Enclosures

- A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). The Contractor shall provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.

- B. FIPs shall contain power supplies for sensors, interface relays and contactors, safety circuits, and I/P transducers.
- C. The FIP enclosure shall be of steel construction with baked enamel finish, NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
- D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
- E. All outside mounted enclosures shall meet the NEMA-4 rating.
- F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

2.6 Identification

- A. Identify all control wires with labeling tape or sleeves using either words, letters, or numbers that can be exactly cross-referenced with as-built drawings.
- B. All field enclosures, other than controllers, shall be identified with a bakelite nameplate. The lettering shall be in white against a black or blue background.
- C. Junction box covers will be marked to indicate that they are a part of the BAS system.
- D. All I/O field devices (except space sensors) that are not mounted within FIP's shall be identified with name plates.
- E. All I/O field devices inside FIP's shall be labeled.

2.7 Location

- A. The location of sensors is per mechanical and architectural drawings.
- B. Space humidity, CO or temperature sensors will be mounted away from machinery generating heat, direct light, and diffuser air streams.
- C. Outdoor air sensors will be mounted on the north building face directly in the outside air. Install these sensors such that the effects of heat radiated from the building or sunlight is minimized.
- D. Field enclosures shall be located immediately adjacent to the controller panel(s) to which it is being interfaced.

2.8 Software Installation

- A. General.

The Contractor shall provide all labor necessary to install, initialize, start-up and debug all system software as described in this section. This includes any operating system software or other third-party software necessary for successful operation of the system.

B. Database Configuration.

The Contractor will provide all labor to configure those portions of the database that are required by the points list and sequence of operation.

C. Color Graphic Slides.

Unless otherwise directed by the owner, the Contractor will provide color graphic displays as depicted in the mechanical drawings for each system and floor plan. For each system or floor plan, the display shall contain the associated points identified in the point list and allow for setpoint changes as required by the owner. Graphically represent every piece of equipment in the classroom building, new and existing, all input and put status point, and functional points. This shall include the new fans, chillers, and convectors, existing boilers, water, fuel, and ejection pumps, fan coil units, convectors, air handlers and fans.

D. Reports.

The Contractor will configure reports for all the equipment listed in section 1.3D. report shall be configured for all input and output points monitored and controlled. As well as the following

Space Temperature Report

E. Documentation

As built software documentation will include the following:

1. Descriptive point lists
2. Application program listing
3. Application programs with comments.
4. Printouts of all reports.
5. Alarm list.
6. Printouts of all graphics

F. Commissioning and System Startup

G. Point to Point Checkout.

Each I/O device (both fields mounted as well as those located in FIPs) shall be inspected and verified for proper installation and functionality. A checkout sheet itemizing each device shall be filled out, dated, and approved by the Project Manager for submission to the owner or owner's representative.

H. Controller and Workstation Checkout.

A field checkout of all controllers and front-end equipment (computers, printers, modems, etc.) shall be conducted to verify proper operation of both hardware and software. A checkout sheet itemizing each device and a description of the associated tests shall be prepared and submitted to the owner or owner's representative by the completion of the project.

I. System Acceptance Testing

All application software will be verified and compared against the sequences of operation. Control loops will be exercised by inducing a setpoint shift of at least 10%

and observing whether the system successfully returns the process variable to setpoint. Record all test results and attach to the Test Results Sheet.

- J. Test each alarm in the system and validate that the system generates the appropriate alarm message, that the message appears at all prescribed destinations (workstations or printers), and that any other related actions occur as defined (i.e., graphic panels are invoked, reports are generated, etc.). Submit a Test Results Sheet to the owner.
- K. Perform an operational test of each unique graphic display and report to verify that the item exists, that the appearance and content are correct, and that any special features work as intended. Submit a Test Results Sheet to the owner.
- L. Perform an operational test of each third-party interface that has been included as part of the automation system. Verify that all points are properly polled, that alarms have been configured, and that any associated graphics and reports have been completed. If the interface involves a file transfer over Ethernet, test any logic that controls the transmission of the file, and verify the content of the specified information.

END OF SECTION

SECTION 23 09 23.11

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.

1.3 DEFINITIONS

- A. Cv: Design valve coefficient.
- B. DDC: Direct-digital control.
- C. NBR: Nitrile butadiene rubber.
- D. PTFE: Polytetrafluoroethylene
- E. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation, operation, and maintenance instructions, including factors affecting performance.

B. Shop Drawings:

1. Include plans, elevations, sections, and mounting details.
2. Include details of product assemblies. Indicate dimensions, weights, loads, and 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 diagrams for pneumatic signal and main air tubing.

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.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation 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. Control valve installation location shown in relationship to room, duct, pipe, and equipment.
 2. Size and location of wall access panels for control valves installed behind walls.
 3. Size and location of ceiling access panels for control valves installed above inaccessible ceilings.

1.6 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, 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. Environmental Conditions:
 - 1. Provide electric control valve actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control valve actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
 - a. Hazardous Locations: Explosion-proof rating for condition.
- G. Body & Trim. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
 - 1. Valve pattern, three-way or straight through, shall be as indicated on Drawings.
 - 2. Modulating two-way pattern control valves shall have equal percentage flow-throttling characteristics unless otherwise indicated.
 - 3. Modulating three-way pattern water valves shall have linear flow-throttling characteristics. The total flow through the valve shall remain constant regardless of the valve's position.
 - 4. Valve bodies shall meet or exceed pressure and temperature class rating based upon design operating temperature and 150% design operating pressure. Unless otherwise specified or scheduled, minimum body rating for any valve is 125 psi and a maximum fluid temperature of 350°F.
 - 5. Valves shall have stainless-steel stems and stuffing boxes with extended necks to clear the piping insulation.
 - 6. Globe valves shall have replaceable seats.
- H. Determine control valve sizes and flow coefficients by ISA 75.01.01.

1. Water Valves. Unless otherwise specified or scheduled, water valves shall follow the following criteria:
 - a. Two-position service: Line size.
 - b. Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through the heat exchanger (coil, load, etc.), 50% of the pressure difference between the supply and return mains, or 5 psi (Maximum).
 - c. Three-way modulating service: Pressure drop shall be equal to twice the pressure drop through the heat exchanger (coil, load, etc.), (5 psi) maximum.
 - d. Valves 1/2" through 2" shall be bronze or cast brass body ANSI Class 250, spring-loaded, PTFE packing quick opening for two-position service.
 - e. Valves larger than 2 1/2" and shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
 - f. Valves 1/2" through 2" shall be ANSI/ASME B1.20.1 (NPT) threaded connections.
 - g. Valves 2 1/2" to 3" shall use flanged connections.
2. Steam Valves. Body and trim style and materials shall be in accordance with the manufacturer's recommendations for design conditions and service shown in compliance with the following at a minimum:
 - a. Linear percentage ports for modulating service.
 - b. Two-position service: Pressure drop 10% to 20% of inlet pressure.
 - c. Modulating service: 15 psig or less; pressure drop 80% of inlet pressure.
 - d. Modulating service: 16-50 psig or less; pressure drop 50% of inlet pressure.
 - e. Modulating service: Greater than 50 psig; pressure drop as scheduled.
- I. Control valve characteristics and rangeability of 50:1 and shall comply with ISA 75.11.01.
- J. Control valve shutoff classifications shall be FCI 70-2, Class IV. Close-Off/Differential Pressure Rating. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure. All valve actuators and trim shall be furnished to provide the following minimum close-off pressure ratings unless otherwise specified or scheduled:
 1. Two-way water valves: 150% of total system (pump) head.
 2. Three-way water valves: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head (whichever is greater).
 3. Steam valves: 150% of operating (inlet) pressure.
- K. Fail positions unless otherwise indicated:
 1. Chilled Water: close
 2. Condenser Water: close
 3. Heating Hot Water: Open.
 4. Steam: Open.
- L. General Characteristics:

1. In water systems, use ball- or globe-style control valves for two-position control for valves NPS 2 and smaller and butterfly style for valves larger than NPS 2. Butterfly valves shall be for open close service only.
2. In steam systems, use ball- or globe-style control valves regardless of size.
3. Pneumatic, two-position control valves shall provide a smooth opening and closing characteristic slow enough to avoid water hammer. Valves with pneumatic actuators shall have an adjustable opening time (valve full closed to full open) and an adjustable closing time (valve full open to full closed) ranging from zero to 10 seconds. Opening and closing times shall be independently adjustable. (Not Used This Project)
4. Control valve, pneumatic-control signal shall not exceed 200 feet. For longer distances, provide an electric/electronic control signal to the valve and an electric solenoid valve or electro-pneumatic transducer at the valve to convert the control signal to pneumatic. (Not Used This Project).
5. Valves for chilled water shall use all internal trim, (including seats, rings, modulating plugs and springs), of 316 stainless steel, regardless of body style.
6. Valves for hot water service between 210F and 250F shall have all internal trim (including seats, rings, modulating plugs and springs) of Type 316 Stainless Steel
7. Valves for hot water service below 210F shall have all internal trim (including seats, rings, modulating plugs and springs) of Brass, Bronze or Type 316 Stainless Steel

2.2 BALL-STYLE CONTROL VALVES

A. General:

1. All control ball valves shall feature characterized flow guides when used for modulating applications.

B. Ball Valves with Single Port and Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Belimo Aircontrols (USA), Inc
2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze or 300 series stainless steel.
9. 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.

10. Ball Seats: Reinforced PTFE.
11. 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.
12. Flow Characteristic: Equal percentage.

C. Ball Valves with Two Ports and Characterized Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Belimo Aircontrols (USA), Inc.
2. Pressure Rating for NPS 1 and Smaller: Nominal 600 WOG.
3. Pressure Rating for NPS 1-1/2 through NPS 2: Nominal 400 WOG.
4. Close-off Pressure: 200 psig.
5. Process Temperature Range: Zero to 212 deg F.
6. Body and Tail Piece: Cast bronze ASTM B 61, ASTM B 62, ASTM B 584, or forged brass with nickel plating.
7. End Connections: Threaded (NPT) ends.
8. Ball: Chrome-plated brass or bronze or 300 series stainless steel].
9. 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.
10. Ball Seats: Reinforced PTFE.
11. 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.
12. Flow Characteristics for A-Port: Equal percentage.
13. Flow Characteristics for B-Port: Modified for constant common port flow.

D. Ball Valves with Single Port and Segmented Ball:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Valve Solutions, Inc.
2. ASME B16.10 face-to-face dimensions.
3. Valves NPS 2 and Smaller: Threaded (NPT) ends.
4. Valves NPS 2-1/2 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
5. Body: Carbon or stainless steel.
6. Ball and Shaft: Stainless steel.
7. Shaft and Segmented Ball: Pinned and welded.

8. Ball Seat: Graphite.
9. Packing: PTFE V-rings and graphite packing follower.
10. Replaceable seat, ball, and shaft packing.
11. Label each valve with following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body size.
 - c. Flow directional arrow.

E. Ball Valves with Segmented Ball, Three-Way Pattern:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Valve Solutions, Inc.
2. Arrangement: Two single-port valves mated to a fabricated tee with interconnecting mechanical linkage.
3. Performance:
 - a. Process Temperature Rating: Minus 20 to plus 450 deg F.
 - b. ASME B16.34, Class 300.
 - c. Leakage: FCI 70-2, Class IV.
 - d. Rangeability: 300 to 1.
 - e. Rotation: Zero to 90 degrees.
 - f. Equal percentage flow characteristic.
4. Face-to-Face Dimensions: ASME B16.10.
5. Valves NPS 3 through NPS 6: Flanged ends suitable for mating to ASME B16.5 flanges.
6. Body: Carbon or stainless steel.
7. Ball and Shaft: Stainless steel.
8. Shaft and Segmented Ball: Pinned and welded.
9. Ball Seat: Graphite.
10. Packing: PTFE V-rings and graphite packing follower.
11. Replaceable seat, ball, and shaft packing.
12. Label each valve with following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body size.
 - c. Flow directional arrow.

F. Ball Valves with Full Ball and Characterized V-Notch:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Flow-Tek, Inc.
2. Performance:

- a. Process Temperature Rating: Minus 20 to plus 500 deg F.
 - b. ASME B16.34, Class 600 for NPS 2 and smaller; Class 150 or Class 300 for larger than NPS 2.
 - c. Leakage: FCI 70-2, Class VI, bi-directional.
 - d. Rangeability: Varies from 200 to 1 up to 800 to 1 based on notch pattern of ball.
 - e. Rotation: Zero to 90 degrees.
 - f. Equal percentage flow characteristic.
 - g. Full port.
 3. Face-to-Face Dimension: ASME B16.10 long pattern.
 4. Valves NPS 2 and Smaller: ASME B1.20.1 threaded (NPT) ends and three-piece body.
 5. Valves NPS 2-1/2 through NPS 12: Flanged ends suitable for mating to ASME B16.5 flanges and two-piece body.
 6. Hole in the stem slot of each ball equalizes pressure between the body cavity and the line media flow.
 7. Replaceable seat, ball, and shaft packing.
 8. Body: Carbon or stainless steel.
 9. Ball and Shaft: Stainless steel.
 10. Ball Seat: RPTFE.
 11. Stem Seals for Valves NPS 2 and Smaller: Live-loaded, self-adjusting, primary and secondary sealing using Belleville washers.
 - a. Primary Seal: Combination of thrust washer and thrust washer protector.
 - b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
 12. Stem Seals for Valves Larger than NPS 2: Independent packing gland, adjusted without removing mounting hardware or operator, and contoured to uniformly distribute load across packing.
 - a. Primary Seal: Combination of thrust washer and thrust washer protector.
 - b. Secondary Seal: Adjustable stem packing composed of RPTFE V-rings.
 13. Label each valve with following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body size.
 - c. Flow directional arrow.
- G. Pressure-Independent Ball Valves NPS 2 and Smaller:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Belimo Aircontrols (USA), Inc.
 - b. HCI; Hydronics Components Inc.
 2. Integral Pressure Regulator: Located upstream of ball to regulate pressure, to maintain a constant pressure differential while operating within a pressure differential range of 5 to 50 psig.

3. Body: Forged brass, nickel plated, and with threaded ends.
4. Ball: Chrome-plated brass.
5. Stem and Stem Extension: Chrome-plated brass, blowout-proof design.
6. Stem sleeve or other approved means to allow valve to be opened and closed without damaging field-applied insulation and insulation vapor barrier seal.
7. Ball Seats: Reinforced PTFE.
8. Stem Seal: Reinforced PTFE packing ring stem seal with threaded packing ring follower to retain the packing ring under design pressure with the linkage removed. Alternative means, such as EPDM O-rings, are acceptable if equivalent cycle endurance can be achieved.
9. Flow Characteristic: Equal percentage.

2.3 BUTTERFLY-STYLE CONTROL VALVES

A. General:

1. Unless otherwise indicated, butterfly valves shall have a minimum range ability of 10:1. All valves shall be guaranteed to have not more than 1% leakage of design flow rate at the pump shut-off pressure.
2. Flanges shall meet all ANSI 125 and ANSI 150 standards.
3. Valve shall have a long stem design to accommodate 2 inches insulation.
- 4.

B. Two-Way Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Keystone; Tyco Flow Control.
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.

C. Three-Way Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Keystone; Tyco Flow Control.

2. Arrangement: Two valves mated to a fabricated tee with interconnecting mechanical linkage.
3. 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.
4. 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.
5. Disc: 316 stainless steel.
6. Shaft: 316 or 17-4 PH stainless steel.
7. Seat: Reinforced EPDM or reinforced PTFE seat with retaining ring.
8. Shaft Bushings: Reinforced PTFE or stainless steel.
9. Replaceable seat, disc, and shaft bushings.
10. 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 GLOBE-STYLE CONTROL VALVES

A. General Globe-Style Valve Requirements:

1. Globe-style control valve body dimensions shall comply with ISA 75.08.01.
2. Construct the valves to be serviceable from the top.
3. For cage guided valves, trim shall be field interchangeable for different valve flow characteristics, such as equal percentage, linear, and quick opening.
4. Reduced trim for one nominal size smaller shall be available for industrial valves NPS 1 and larger.
5. Replaceable seats and plugs.
6. Furnish each control valve with a corrosion-resistant nameplate indicating the following:
 - a. Manufacturer's name, model number, and serial number.
 - b. Body and trim size.
 - c. Arrow indicating direction of flow.

B. Two-Way Globe Valves NPS 2 and Smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johnson Controls, Inc.
2. Globe Style: Single port.

3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
4. End Connections: Threaded.
5. Bonnet: Screwed.
6. Packing: PTFE V-ring.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.
12. Rangeability: 25 to 1.
13. Equal percentage flow characteristic.

C. Three-Way Globe Valves NPS 2 and Smaller:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johnson Controls, Inc.
2. Globe Style: Mix flow pattern.
3. Body: Cast bronze or forged brass with ASME B16.5, Class 250 rating.
4. End Connections: Threaded.
5. Bonnet: Screwed.
6. Packing: PTFE V-ring.
7. Plug: Top guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Range: 35 to 248 deg F.
10. Ambient Operating Temperature: 35 to 150 deg F.
11. Leakage: FCI 70-2, Class IV.
12. Rangeability: 25 to 1.
13. Linear flow characteristic.

D. Two-Way Globe Valves NPS 2-1/2 to NPS 6:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johnson Controls, Inc.
2. Globe Style: Single port.
3. Body: Cast iron complying with ASME B61.1, Class 125.
4. End Connections: Flanged, suitable for mating to ASME B16.5, Class 150 flanges.
5. Bonnet: Bolted.
6. Packing: PTFE cone-ring.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 deg F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

E. Three-Way Globe Valves NPS 2-1/2 to NPS 6:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Johnson Controls, Inc.
2. Globe Style: Mix flow pattern.
3. Body: Cast iron complying with ASME B61.1, Class 125.
4. End Connections: Flanged suitable for mating to ASME B16.5, Class 150 flanges.
5. Bonnet: Bolted.
6. Packing: PTFE cone-ring.
7. Plug: Top or bottom guided.
8. Plug, Seat, and Stem: Brass or stainless steel.
9. Process Temperature Rating: 35 to 281 deg F.
10. Leakage: 0.1 percent of maximum flow.
11. Rangeability: Varies with valve size between 6 and 10 to 1.
12. Modified linear flow characteristic.

2.5 SOLENOID VALVES

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. ASCO Valve, Inc.
- B. 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.

2.6 SELF-CONTAINED TEMPERATURE REGULATING VALVE

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Jordan Valve; Richards Industries Company.
- B. Description:
1. Self-contained and self-operated temperature regulating valve. Direct acting or reverse acting as required by application.

2. Direct Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn closing the valve. The valve shall fail open.
 3. Reverse Acting: A rise in temperature at the sensing bulb vaporizes some of the liquid in the bulb, forcing the remaining liquid through a capillary to apply pressure at the diaphragm, in turn opening the valve. The valve shall fail close.
 4. Body: Carbon steel.
 5. Trim and Seats: 300 series stainless steel.
 6. Yoke: Cast iron.
 7. Actuator: 300 series stainless steel.
 8. End Connections: Threaded.
 9. Capillary, Bulb, and Armor: 300 series stainless steel.
 10. Thermal Fill Material: Match to the temperature range.
 11. Thermowell: Type 316 stainless-steel thermowell sized to fit the bulb and pipe.
- C. Operational Characteristics: Control flow from between 5 to 100 percent of rated capacity.
- D. Interchangeable trim for one size smaller.
- E. Valve Leakage: Comply with FCI 70-2, Class IV.
- F. Temperature Range: Match application.
1. Drains from Hot Equipment to Sanitary Sewer System: 105 to 165 deg F.
- G. Valve Size: Size to pass the design flow required with not more than 95 percent of the stem lift while operating at design pressure.

2.7 ELECTRIC AND ELECTRONIC CONTROL VALVE ACTUATORS

- A. Actuators for Hydronic Control Valves: Capable of closing valve against system pump shutoff head.
- B. Actuators for Steam Control Valves: Shutoff against 1.5 times steam design pressure.
- C. Position indicator and graduated scale on each actuator.
- D. Type: Motor operated, with or without gears, electric and electronic.
- E. Voltage: 24-V ac.
- F. Deliver torque required for continuous uniform movement of controlled device from limit to limit when operated at rated voltage.
- G. Function properly within a range of 85 to 120 percent of nameplate voltage.
- H. 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.
 4. All control valves shall have a visual position indicator.
 5. All non-spring return actuators shall have an external clutch/manual gear release to allow manual positioning of the valve when the actuator is not powered. Spring return actuators with more than 60-in-LB torque capacity shall have a manual crank for this purpose. In lieu of a manual positioning device, it will be acceptable for the contractor to provide a full line size bypass around the control valve. Three bypass shut off valves shall be provided to allow the control valve to be isolated while the open stop valve in the bypass allows flow around the control valve.
- I. 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.
- J. Two-Position Actuators: Single direction, spring return or reversing type.
- K. 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 counterclockwise 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 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.

3. All modulating actuators shall have an external, built-in switch to allow the reversing of direction of rotation.

L. Position Feedback:

1. Equip where indicated 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 where indicated, 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.

M. 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.
4. Any mechanical equipment with direct introduction of outside air shall require fail-safe spring return valve actuators. Terminal equipment (VAV ATU, &c.) without direct introduction of outside air is permitted to have actuators that maintain their last commanded position when power is lost to the actuator. Equipment isolation and differential or temperature pressure bypass valves shall not be required to be provided with a spring return actuator provided that a failure of the valve to return to its "fail-safe" position will not incur damage to property or the system it serves.

N. 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.

O. 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.

P. 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.

Q. 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.
5. Actuators used in wet conditions and/or in or near outdoor air streams shall have NEMA 2 housings.

R. Stroke Time:

1. Operate valve from fully closed to fully open within 60 75 90 150 Insert number 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.

S. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.8 POWER SUPPLIES AND LINE FILTERING

- A. Power Supplies & Control Transformers. Control transformers and power supplies shall be UL-Listed. Provide Class 2 current-limiting type or over-current protection in both primary and secondary circuits for Class 2 service not to exceed 100 VA in accordance with the applicable following requirements or as directed by the AHJ.
1. NEC 2011 (NFPA 70) Chapter 7 Article 725 – Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits.
 2. NEC 2011 (NFPA 70) Chapter 9 Table 11(A) and Table 11(B).
 3. Canadian Electrical Code, Part 1 (CSA C22.1-12) Rule 16-200.
- B. DC Power Supplies. DC power supply output shall match output current and voltage requirements. Power supply shall be half-wave rectified type with the following minimum specifications:
1. Output ripple: 5.0 mV maximum peak-to-peak.
 2. Regulation: 1.0% line and load combined.
 3. Response: 100 ms for 50% load changes.
 4. Built-in overvoltage and overcurrent protection and able to withstand a 150% current overload for a minimum of three (3) seconds without tripping or failure.
- C. Power Line Filtering. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.
- D. Valve Actuators shall be modulating, floating (tri-state) with feedback signal, two-position and spring return fail safe as called out in the control sequence of operation or indicated on the drawings. All modulating valves shall be positive positioning and respond to a [0-10VDC] [2-10 VDC] [4-20 mA with a load resistor] with the exception

that terminal unit zone valves may use an actuator that responds to a floating or tri-state with feedback signal.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for valves installed in piping to verify actual locations of piping connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL VALVE APPLICATIONS

- A. Unless otherwise noted, controls valves shall be globe pattern.
- B. Do not use butterfly valves for steam service or modulating applications.

3.3 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 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.

3.4 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, as per electrical specifications.
- D. Furnish and install raceways as per electrical specifications.
- E. Electrical subcontractor shall provide all required line voltage. The mechanical subcontractor shall provide all low voltage wiring and power supply transformers in coordination with the control's subcontractor and control actuator requirements.

3.5 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. Where indicated, install control valve with three-valve bypass manifold to allow for control valve isolation and removal without interrupting system flow by providing manual throttling valve in bypass pipe.
- D. Install drain valves in piping upstream and downstream of each control valve installed in a three-valve manifold and for each control valve larger than NPS 4.
- E. Install pressure temperature taps in piping upstream and downstream of each control valve larger than NPS 2.
- F. Valve Orientation:
 - 1. Where possible, install globe and ball valves installed in horizontal piping with stems upright and not more than 15 degrees off 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.
- G. 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.
- H. 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.
- I. 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.

3.6 CONNECTIONS

- A. Connect electrical devices and components to electrical grounding system. Comply with electrical specifications.

3.7 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 230553.
- B. Install engraved phenolic nameplate with valve identification on valve.

3.8 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.

3.9 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. For pneumatic products, verify air supply for each product is properly installed.
 - 5. For pneumatic valves, verify that pressure gauges are provided in each airline to valve actuator and positioner.
 - 6. Verify that control valves are installed correctly for flow direction.
 - 7. Verify that valve body attachment is properly secured and sealed.
 - 8. Verify that valve actuator and linkage attachment are secure.
 - 9. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
 - 10. Verify that valve ball, disc, and plug travel are unobstructed.
 - 11. 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.

3.10 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

SECTION 23 09 23.12

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. Pneumatic actuators.
 - 4. Electric and electronic actuators.

1.3 DEFINITIONS

- A. DDC: Direct-digital control.
- B. RMS: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product, including the following:
 - 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 3. Product description with complete technical data, performance curves, and product specification sheets.
 - 4. Installation instructions, including factors affecting performance.
- 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 diagrams for air and process signal tubing.
5. Include diagrams for pneumatic signal and main air tubing.

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.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation 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. Product installation location shown in relationship to room, duct, and equipment.
 2. Size and location of wall access panels for control dampers and actuators installed behind walls.
 3. Size and location of ceiling access panels for control dampers and actuators installed above inaccessible ceilings.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For control dampers to include in operation and maintenance manuals.

PART 2 PRODUCTS

2.1 PERFORMANCE AND GENERAL REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label products to comply with ASME Boiler and Pressure Vessel Code where required by authorities having jurisdiction.
- C. Ground Fault: Products shall not fail due to ground fault condition when suitably grounded.
- D. Backup Power Source: Systems and equipment served by a backup power source shall have associated control damper actuators served from a backup power source.
- E. All Automatic Control Dampers provided as a part of this Specification shall bear the AMCA Seal as an indication that they comply with all requirements of the AMCA Certified Ratings Programs.
- F. Maximum leakage rate through any 48 inches by 48 inches closed damper in any application shall not exceed 10.0 cfm per sq. ft. of damper face area at 4 inches of water pressure differential and a maximum closing torque of 4 inch-lbs./sq. ft. of damper face area. Damper leakage ratings shall be certified in accordance with AMCA Standard 500-D.
- G. Environmental Conditions:
 - 1. Provide electric control-damper actuators, with protective enclosures satisfying the following minimum requirements unless more stringent requirements are indicated. Electric control-damper actuators not available with integral enclosures, complying with requirements indicated, shall be housed in protective secondary enclosures.
 - a. Hazardous Locations: Explosion-proof rating for condition.
 - b. All outdoor air damper components shall be suitable for applications operating in the temperature range of -40F to 167F.
- H. Selection Criteria:
 - 1. Fail positions unless otherwise indicated:
 - a. Supply Air: Open.
 - b. Return Air: Open.
 - c. Outdoor Air: Close.
 - d. Mixed Air: Open.
 - e. Exhaust Air: Close.

2. Dampers shall have stable operation throughout full range of operation, from design to minimum airflow over varying pressures and temperatures encountered.
3. Select modulating dampers for a pressure drop of 5 percent of fan total static pressure unless otherwise indicated.
4. Two-position dampers shall be full size of duct or equipment connection unless otherwise indicated.
5. Unless otherwise indicated, use parallel blade configuration for two-position control, equipment isolation service. Use opposed blade configuration for modulating, mixing and any application of upstream critical components.
6. Pneumatic, two-position control dampers shall provide a smooth opening and closing characteristic slow enough to avoid excessive pressure. Dampers with pneumatic actuators shall have an adjustable opening time (valve full closed to full open) and an adjustable closing time (valve full open to full closed) ranging from zero to 10 seconds. Opening and closing times shall be independently adjustable. (Not Used for This Project)
7. Control-damper, pneumatic-control signal shall not exceed 200 feet. For longer distances, provide an electric/electronic control signal to the damper and an electric solenoid valve or electro-pneumatic transducer at the damper to convert the control signal to pneumatic. (Not Used for This Project)

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. 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. Ruskin Company.
 - b. Arrow louver and Damper co.
 - c. Nailer Hart
 - d. Greenheck
2. 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.
3. 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 galvanized plated or 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: (Not Used)
 - 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.
- 4. Airflow Measurement:
 - 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) Ruskin Company.
 - b. Where indicated, provide damper assembly with integral airflow monitoring.
 - c. Zero- to 10-V dc or 4- to 20-mA scaled output signal for remote monitoring of actual airflow.
 - d. 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.
 - e. Provide a straightening device as part of the flow measurement assembly to achieve the specified accuracy with configuration indicated.
 - f. Suitable for operation in untreated and unfiltered air.
 - g. Provide temperature and altitude compensation and correction to maintain accuracy over temperature range encountered at site altitude.
 - h. Provide automatic zeroing feature.
- 5. Airflow Control:
 - 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) Ruskin Company.
 - b. Where indicated, provide damper assembly with integral airflow measurement and control.
 - c. A factory-furnished and -calibrated controller shall be programmed, in nonvolatile EPROM, with application-specific airflow set point and range.
 - d. The controller and actuator shall communicate to control the desired airflow.
 - e. The controller shall receive a zero- to 10-V dc input signal and report a zero- to 20-mA output signal that is proportional to the airflow.
 - f. Airflow measurement and control range shall be suitable for operation between 150 to 2000 fpm.

- g. Ambient Operating Temperature Range: Minus 40 to plus 140 deg F.
- h. Ambient Operating Humidity Range: 5 to 95 percent relative humidity, non-condensing.
- i. Provide unit with control transformer rated for not less than 85 VA. Provide transformer with primary and secondary protection and primary disconnecting means. Coordinate requirements with field power connection.
- j. Provide screw terminals for interface to field wiring.
- k. Factory mount electronics within a NEMA 250, Type 1 painted steel enclosure.

C. Industrial-Duty Rectangular Dampers with Steel Airfoil Blades:

- 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Ruskin Company.
 - b. Arrow Louver and Damper Co.
 - c. Nailer Hart
 - d. Greenheck
- 2. Performance:
 - a. Leakage: Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure.
 - b. Pressure Drop: 0.06-in. wg at 2000 fpm across a 48-by-48-inch damper when tested according to AMCA 500-D, figure 5.3.
 - c. Velocity: Up to 4000 fpm.
 - d. Temperature: Minus 40 to plus 250 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, minimum 10-in. wg.
- 3. Construction:
 - a. Frame:
 - 1) Material: Galvanized or stainless steel, 0.11 inch thick.
 - 2) C-shaped channel. Mating face shall be a minimum of 1 inch.
 - 3) Width not less than 3 inches.
 - b. Blades:
 - 1) Hollow, airfoil, galvanized or stainless steel.
 - 2) Parallel or opposed blade configuration as required by application.
 - 3) Material: Galvanized or stainless steel, 0.06 inch thick.
 - 4) Width not to exceed 6 inches.
 - 5) Length not to exceed 48 inches.
 - c. Seals:

- 1) Blades: Replaceable, mechanically attached EPDM or extruded silicone.
 - 2) Jambs: Stainless steel, double compression type.
 - d. Axles: 0.5- or 0.75-inch- diameter stainless steel, mechanically attached to blades and continuous from end to end.
 - e. Bearings:
 - 1) Stainless-steel sleeve type mounted in frame.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
 - f. Linkage:
 - 1) Face linkage exposed to airstream.
 - 2) Constructed of plated or stainless steel.
 - 3) Hardware: Stainless steel.
- D. Insulated Rectangular Dampers:
 1. Performance:
 - a. Leakage: AMCA 511, Class 1A. Leakage shall not exceed 3 cfm/sq. ft. against 1-in. wg differential static pressure and shall not exceed 4.9 cfm/sq. ft. against 4-in. wg differential static pressure at minus 40 deg F.
 - b. Pressure Drop: 0.1-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 4000 fpm.
 - d. Temperature: Minus 100 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, 0.08 inch thick.
 - 2) C-shaped channel with integral flange(s). Mating face shall be a minimum of 1 inch.
 - 3) Width not less than 4 inches.
 - 4) Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - 5) Damper frame shall be insulated with polystyrafoam on four sides.
 - b. Blades:
 - 1) Hollow shaped, extruded aluminum.

- 2) Blades shall be internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - 3) Parallel or opposed blade configuration as required by application.
 - 4) Material: ASTM B 211, Alloy 6063 T5 aluminum, 0.08 inch thick.
 - 5) Width not to exceed 6 inches.
 - 6) Length as required by close-off pressure, not to exceed 48 inches.
- c. Seals: Blade and frame seals shall be of flexible silicone and secured in an integral slot within the aluminum extrusions.
- d. Axles: 0.44-inch- diameter plated or stainless steel, mechanically attached to blades.
- e. Bearings:
- 1) Bearings shall be composed of a Celcon inner bearing fixed to axle, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
 - 2) Where blade axles are installed in vertical position, provide thrust bearings.
- f. Linkage:
- 1) Concealed in frame.
 - 2) Constructed of aluminum and plated or 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.

2.3 GENERAL, OPERATING LINKAGES AND DAMPER ACCESSORIES

- A. All operating linkages and/or damper accessories required for installation and application in accordance with specification design intent and manufacturer's installation procedures shall be provided.

- B. Operating linkages provided external to dampers (crank arms, connecting rods, shaft extensions, &c.) for transmitting motion from the actuator/operator to dampers shall be designed as to functionally operate a load equal to or more than 300% of the maximum required operating force for the damper.
- C. Crank arms and connecting rods shall be adjustable. Linkages shall be brass, bronze, zinc-coated steel, or stainless steel.
- D. Adjustments of Crank Arms shall control the position of the damper.
- E. Use of Operating Linkages external to damper drive shaft shall neither delay nor impede operation of the damper in a manner of performance less than a direct-coupled damper actuator. Operating linkages shall not under any circumstances be permitted to flex, warp, shift &c. under normal operation of connected damper sections.

2.4 GENERAL, CONTROL-DAMPER ACTUATORS REQUIREMENTS

- A. A. Control damper actuators shall be electronic direct-coupled OR pneumatic pilot/positioned type. Actuators shall have a means for reversing drive direction and a manual override accessible at the front cover.
- B. 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.
- C. 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.
- D. The total damper area operated by an actuator shall not exceed 80 percent of manufacturer's maximum area rating.
- E. Provide one actuator for each damper assembly where possible. Multiple actuators required to drive a single damper assembly shall operate in unison.
- F. 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.
- G. Use jackshafts and shaft couplings in lieu of blade-to-blade linkages when driving axially aligned damper sections.
- H. Provide mounting hardware and linkages for connecting actuator to damper. Single bolt or setscrew type fasteners are not acceptable.
- I. Select actuators to fail in desired position in the event of a power failure. For spring return fail-safe applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

- J. Actuator Fail Positions: As indicated below refer to sequence of operations for additional information regarding specific equipment:
 - 1. Exhaust Air: Close.
 - 2. Outdoor Air: Close.
 - 3. Supply Air: Open.
 - 4. Return Air: Open.
- K. All non-spring return actuators shall have an external manual clutch/gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-LB torque capacity shall have a manual crank for this purpose.

2.5 ELECTRIC AND ELECTRONIC ACTUATORS

- A. Type: Motor operated, with or without gears, electric and electronic.
- B. Voltage:
 - 1. 24 V.
 - 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.
- C. 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.
- D. 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.
- E. Two-Position Actuators: Single direction, spring return or reversing type.
- F. 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 counterclockwise 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: (Not Used)
 - 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.

G. Position Feedback:

1. Equip where indicated, 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 where indicated, 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.

H. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. Stroke Time:

1. Operate damper from fully closed to fully open within 60 75 90 150.
2. Operate damper from fully open to fully closed within 60 75 90 150.
3. Move damper to failed position within 15 30 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.

N. Sound:

1. Spring Return: 62 dBA.
2. Non-Spring Return: 45 dBA.

2.6 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies & Control Transformers. Control transformers and power supplies shall be UL-Listed. Provide Class 2 current-limiting type or over-current protection in both primary and secondary circuits for Class 2 service not to exceed 100 VA in accordance with the applicable following requirements or as directed by the AHJ.

1. NEC 2011 (NFPA 70) Chapter 7 Article 725 – Class 1, Class 2 and Class 3 Remote-Control, Signaling and Power-Limited Circuits.
2. NEC 2011 (NFPA 70) Chapter 9 Table 11(A) and Table 11(B).
3. Canadian Electrical Code, Part 1 (CSA C22.1-12) Rule 16-200.

B. DC Power Supplies. DC power supply output shall match output current and voltage requirements. Power supply shall be half-wave rectified type with the following minimum specifications:

1. Output ripple: 5.0 mV maximum peak-to-peak.
2. Regulation: 1.0% line and load combined.
3. Response: 100 ms for 50% load changes.
4. Built-in overvoltage and overcurrent protection and able to withstand a 150% current overload for a minimum of three (3) seconds without tripping or failure.

- C. Power Line Filtering. Provide transient voltage and surge suppression for all workstations and controllers either internally or as an external component.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for dampers and instruments installed in duct systems to verify actual locations of connections before installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CONTROL-DAMPER APPLICATIONS

- A. Control Dampers:
 - a. Use opposed blade type dampers for all modulating damper applications.
 - b. Use parallel blade type damper for all open closed applications.
 - c. Damper actuation stroke time shall be adjustable.
 - d. Damper position feedback is required for all dampers that are part of a smoke purge or smoke control system.

3.3 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 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.

3.4 ELECTRIC POWER

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements of the electrical specifications.
- C. Furnish and install power wiring. Comply with requirements of the electrical specifications.
- D. Furnish and install raceways. Comply with requirements of the electrical specifications.
- E. Electrical subcontractor shall provide all required line voltage. The mechanical subcontractor shall provide all low voltage wiring and power supply transformers in coordination with the control's subcontractor and control actuator requirements.

3.5 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.

3.6 CONNECTIONS

- A. Connect electrical devices and components to electrical grounding system. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.7 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 230553.
- B. Install engraved phenolic nameplate with damper identification on damper.

3.8 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. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
4. For pneumatic products, verify air supply for each product is properly installed.
5. For pneumatic dampers, verify that pressure gages are provided in each airline to damper actuator and positioner.
6. Verify that control dampers are installed correctly for flow direction.
7. Verify that proper blade alignment, either parallel or opposed, has been provided.
8. Verify that damper frame attachment is properly secured and sealed.

9. Verify that damper actuator and linkage attachment are secure.
10. Verify that actuator wiring is complete, enclosed, and connected to correct power source.
11. Verify that damper blade travel is unobstructed.

3.9 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. Stroke control dampers with pilot positioners. Adjust damper and positioner following manufacturer's recommended procedure, so damper is 100 percent closed, 50 percent closed, and 100 percent open at proper air pressure.
- C. Check and document open and close cycle times for applications with a cycle time of less than 30 seconds.
- D. For control dampers equipped with positive position indication, check feedback signal at multiple positions to confirm proper position indication.

END OF SECTION

SECTION 23 09 93

SEQUENCE OF OPERATIONS

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Sequence of operation:
 - 1. Summer - Winter change over
 - 2. Geothermal System
 - 3. Dual Temperature Variable Speed Pumping System Control
 - 4. Air Handling Units
 - 5. Unit Heaters
 - 6. Exhaust fans
 - 7. Ductless split systems
 - 8. Air Conditioning Condensate Pumps
 - 9. Miscellaneous Plumbing Equipment

1.2 SYSTEM DESCRIPTION

- A. This Section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other Sections.
- B. Provide DDC based electronic controls, panels, wiring and all accessories required to achieve the specified control sequences and establish a complete independent system for all new equipment. In general, the equipment shall be controlled through Standalone Digital Control Units (SDCUs).

BMS shall include status of all motorized valves, dampers, equipment, pumps such that operation and position of all equipment is visible at BMS front end.

Provide the necessary quantity and types of SDCUs to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each SDCU will operate completely standalone, containing all of the I/O and programs to control its associated equipment.

Certain controls are specified to be furnished with the equipment. This contractor shall provide all components to communicate with factory furnished controls and connect them to the building automation control system. This contractor shall be responsible to review equipment submittals and review and review the controls provided with all packaged equipment to ensure that the equipment is ordered with eh appropriate gateways and MPTP controllers for integration to the BMS (Building Management System) system. The contractor shall also provide all controls, wiring and auxiliaries required to operate

equipment not furnished with factory controls. Work required includes, but is not limited to the following:

1. Control wiring between factory mounted unit panels and factory supplied remote panels.
 2. Installation and wiring for factory supplied devices requiring field installation.
 3. Panel mounted transformers and control power wiring for all controllers and control devices.
 4. Control wiring to each remote device (room thermostats, outdoor air sensors, static pressure controllers, control actuators, control panels, etc.).
 6. All control valves, motorized dampers thermostats, relays, sensors, etc. unless furnished as an integral part of the equipment.
 7. All interlock control wiring (24 volt and 120 volt) between units, fans, etc.
- C. All control and interlock wiring shall be run in EMT for indoor locations and in galvanized conduit for outdoor locations.

1.3 SUBMITTALS FOR REVIEW

- A. Division 1 - Submittals: Procedures for submittals.
- B. Shop Drawings: Indicate mechanical system controlled and control system components.
1. Label with settings, adjustable range of control and limits. Include written description of control sequence.
 2. Include flow diagrams for each control system, graphically depicting control logic.
 3. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
 4. Submit a complete written sequence of operation for every controlled piece of equipment.

1.4 SUBMITTALS AT PROJECT CLOSEOUT

- A. Operation and Maintenance Data.
- B. Project Record Documents: Record actual locations of components and set points of controls, including changes to sequences made after submission of shop drawings.

1.5 QUALITY ASSURANCE

- A. Design system under direct supervision of a Professional Engineer experienced in design of this Work and licensed in the State of New York.

PART 2 EXECUTION

2.1 SUMMER/WINTER CHANGEOVER

- A. The Building Automation System (BAS) shall index the building into either summer or winter mode based upon outdoor air temperature. Below 65° F (adjustable) outside air temperature, the cooling system shall be disabled. Above 55°F (adjustable) outside air temperature the heating system shall disabled. The system operator shall have capacity of overriding the system for manual enabling of the heating or cooling systems. A minimum time delay (8 hrs. adjustable) between summer/winter change-over shall prevent cycling between the 2 modes.

2.2 GEOTHERMAL WATER PUMPS (GWP-1 AND GWP-2)

A. PRIMARY GEOTHERMAL WATER PUMPS:

- 1. The primary geothermal pumps shall run continuously whenever there is a call for heating or cooling. Lead primary pump selection shall be made by control system automatically on a daily or weekly basis. Upon lead pump failure as sensed by the geothermal water pump status switch and after an adjustable time delay, the lag pump shall be energized, and the lead pump shall be locked out.
- 2. Differential pressure shall be measured across the supply and return of the variable primary system using a manifold differential pressure sensor. The differential pressure will be measured at the ends of the piping mains. The speed of the pump will be sequenced with the differential pressure bypass valve to maintain the differential pressure at (15 psi adjustable). If the differential pressure drops below set point, the bypass valve shall modulate towards the closed position. Upon the bypass valve reaching the full closed position the pump speed shall increase proportionately, if differential pressure rises above set point, the pump speed shall be decreased proportionately. When pump speed reaches its minimum then the bypass valve shall modulate toward the open position. Differential pressure set points shall be programmable at the operator workstation.
- 3. Operator Station Display: Indicate the following on the operator workstation display terminal:
 - a. Pump status.
 - b. Pump start/stop.
 - c. Pump in hand.
 - d. Pump failure alarm via flow switch.
 - e. VFD speed.
 - f. VFD fault.
 - g. VFD in by-pass.

2.3 DUAL TEMP WATER PUMPS (DTP-1 AND DTP-2)

A. PRIMARY DUAL TEMP WATER PUMPS:

1. The primary dual temperature pumps shall run continuously whenever there is a call for heating or cooling. Lead primary pump selection shall be made by control system automatically on a daily or weekly basis. Upon lead pump failure as sensed by the dual temperature water pump status switch and after an adjustable time delay, the lag pump shall be energized, and the lead pump shall be locked out.
2. Differential pressure shall be measured across the supply and return of the variable primary system using a manifold differential pressure sensor. The differential pressure will be measured at the ends of the piping mains. The speed of the pump will be sequenced with the differential pressure bypass valve to maintain the differential pressure at (15 psi adjustable). If the differential pressure drops below set point, the bypass valve shall modulate towards the closed position. Upon the bypass valve reaching the full closed position the pump speed shall increase proportionately, if differential pressure rises above set point, the pump speed shall be decreased proportionately. When pump speed reaches its minimum then the bypass valve shall modulate toward the open position. Differential pressure set points shall be programmable at the operator workstation.
3. Operator Station Display: Indicate the following on the operator workstation display terminal:
 - a. Pump status.
 - b. Pump start/stop.
 - c. Pump in hand.
 - d. Pump failure alarm via flow switch.
 - e. VFD speed.
 - f. VFD fault.
 - g. VFD in by-pass.

2.4 WATER TO WATER HEAT PUMPS

The water to water heat pumps shall be controlled via a factory controller. Units shall be operational and energized upon a call for heating or cooling.

Unit shall be equipped with a factory installed DDC control capable of interfacing with BacNet, Modbus, N2 and LonWorks. The controller shall be preprogrammed to control the unit and monitor the safety controls. The unit shall be able to operate as a standalone or be incorporated into the building management system. A leaving water and leaving air sensor shall be installed in the unit. Wall sensors shall be available for controlling zone temperature (if used in conjunction with hydronic fan coil).

Units shall have all the features above (UPM) and the state of the art WSHP multiple protocol interface board (Direct Digital Control (DDC)) will have the ability to be viewed in the Control Air M, Control Air M+, Virtual Control Air M (Equipment Touch™ App), or

Field Assistant user interface. All point objects will have the ability to be viewed in the Control Air M user interface. The following points must be available at a central or remote computer location:

1. Leaving water temperature
2. Fan run time
3. Override time remaining
4. Night setback status
5. Percent of units cooling
6. Percent of units heating
7. Cooling set point
8. Heating set point
9. Status of all the alarms
10. Occupied heating and cooling set points
11. Command for occupied or unoccupied mode
12. Command for override of the unoccupied mode (unit resorts to occupied set points)
13. Set point adjustment
14. Itemized fault code viewed with Control Air M interface

2.5 FANS

A. TOILET EXHAUST FANS (all fans designated TX)

1. Toilet exhaust fans shall run continuously while in the occupied mode, during the unoccupied mode the toilet exhaust fans shall be off. Provide motorized damper for each toilet exhaust fan arranged to open upon toilet exhaust fan activation and close upon toilet exhaust fan deactivation. Toilet exhaust fan shall not energize until motorized damper is proven open.
2. Operator Station Display: Indicate the following on the operator workstation display terminal:
 - a. Fan Status.
 - b. Fan start/stop.
 - c. Fan failure via flow switch.
 - d. Fan in hand.
 - e. Motorized damper status.
 - f. Schedule.
 - g. Fan runtime exceeded.

2.6 AIR HANDLING UNITS AND RELIEF FANS:

General Notes

Air Handler Units are a constant air volume unit with supply fan, dual temperature coil, and outdoor air dampers.

Occupancy, Scheduling and Commands

Scheduling

The area related to this AHU will be assigned to a fully user adjustable occupancy schedule (schedule to be coordinated with the owner).

Optimum Start

Optimum start prepares the space for occupancy in advance of the occupied period. By starting heating or cooling at the optimum time before the occupied period begins, the controller provides a comfortable space ready for occupancy without wasting energy. The system will maintain statistics comparing the outside temperature to the time required for the space to reach the occupied set points. The system uses these statistics to calculate the length of time required for optimum start. The user can enable or disable the optimum start feature by setting the user adjustable Optimum Start Option. The user can also limit the maximum time that the unit will start be for its occupied state by setting an adjustable Optimum Max Time to 60 minutes. Whenever the AHU is called to run during optimum start mode the controller will operate as if it was occupied.

Local User Override

The associated wall thermostat will allow the local user (someone in the space) to override the AHU into an occupied mode. Whenever the AHU controller detects this override then the AHU will switch into an occupied mode and operate as detailed below.

Unit Shutdown

Whenever the unit shuts down, the fan will cycle OFF, chilled water (CHW) coil valve will be closed, the hot water (HW) coil valve will modulate to maintain the active space heating setpoint as detailed below. If the condensate pan high water level goes into alarm then the controller will fully close the CHW valve, command the supply fan OFF, and report the alarm condition to the front-end.

AHU Operation

Each unit shall be supplied with and operated through a unit mounted DDC unitary control panel, capable of providing set-point adjustments and all programming control sequences. Controls shall include all motorized dampers, damper motors, control valves, actuators, motor starters, wiring, sensors and all hardware accessories for a complete system. Units shall be provided with all required modules and accessories to allow open communications, and integration with other DDC Control system and the BMS network including summer/winter change over.

Occupied

AHU outdoor air damper shall open to its minimum position. While occupied the controller will enable the supply fan to operate at speed as noted in schedule. The factory mounted controller shall modulate the outdoor air dampers and the dual temperature coil valve to maintain desired space temperature. Exhaust Fans shall operate at minimum setting when the AHU zones are in Occupied Mode. Relief air dampers shall be closed. Classrooms shall have positive space pressurization.

Summer Mode:

Whenever the supply fan is running, the controller will modulate the Dual Temperature coil valve to maintain the space temperature to an adjustable Occ

Space Cooling Setpoint of 74 DEG (F). If the valve modulates up to a fully open position and cannot satisfy the cooling demand, then the controller will modulate the supply fan speed between its minimum and maximum speeds as needed to satisfy the space temperature.

Winter Mode:

Whenever the supply fan is running, the controller will modulate the Dual Temperature coil valve to maintain the space temperature to an adjustable Occ Space Heating Setpoint of 70 DEG (F). If the valve modulates up to a fully open position and cannot satisfy the heating demand, then the controller will modulate the supply fan speed between its minimum and maximum speeds as needed to satisfy the space temperature.

Economizer Mode:

Unit supply fan shall run continuously. The outside air damper shall be open. A temperature sensor in the unit discharge shall be arranged to modulate the waterside economizer control valve to maintain discharge temperature to satisfy and maintain space temperature setpoint (65 Deg F) adjustable. Control action shall be that a rise in discharge air temperature shall increase flow to the economizer coil. When full flow is achieved through the coil, a further increase in discharge air temperature shall revert the unit back to mechanical cooling. Upon a drop-in discharge temperature the reverse shall occur. Economizer mode shall be enthalpy based.

Relief Fans:

1. Relief fans shall be interlocked with their respective AHU units such that when its AHU is energized the RF-# shall be energized. Relief fan speed shall modulate to track their associated AHU supply fan speed and OA Damper position to maintain positive building pressure. Provide space pressure sensors.
2. Operator Station Display: Indicate the following on operator workstation display terminal:
 - a. Fan status.
 - b. Fan start/stop.
 - c. Fan VFD fault.
 - d. Fan VFD speed.
 - e. Fan VFD speed adjust.
 - f. Fan Failure via air proving switch.
 - g. Space pressure sensor.

Unoccupied

Winter Mode:

While unoccupied and if the space is satisfied, the supply fan will cycle OFF, the dual temperature valve(s) will modulate and maintain the space to unoccupied space heating setpoint.

Summer Mode:

If the space temperature increases above an adjustable Unoccupied Space Cooling Setpoint of 85 DEG (F) then the AHU will cycle ON and run at its maximum speed and the dual temperature valve will move to a fully open position to cool the room

quickly and minimize equipment runtime. When the space temperature drops 4 DEG (F) below this setpoint then the valve will close, and the AHU will cycle OFF.

Alarms and Graphics

Alarms

All the inputs on this controller will be monitored by the front-end web server and will provide alarm notification upon detection of an alarm condition (via the alarm log, email and/or text). The controller will also verify the input status to the output control signals and provide alarm notification to the system upon detection of an alarm condition. This alarming should be understood throughout the system, even if they are not all specifically detailed within this sequence of operations.

Graphics

The front-end web-based system will include a complete graphical representation of this control system and all its associated points, alarms, setpoints, schedules, sequences as detailed within this sequence and the HVAC Controls portion of the project plans, as well as what is required to make this system fully operational and user friendly.

General:

All air handlers operate with Dual Temperature Water. Provide digital programmable thermostat for each unit.

Provide low-limit thermostat (freeze-stat) which shall de-energize fan, shall open the heating valve, and close the outdoor air damper if the discharge air temperature decreases to below 36 deg F (adjustable). Alarm, visual and audible, shall indicate on BMS.

2.7 DUCTLESS SPLIT SYSTEMS

General Notes:

Ductless split system AC units (AC Unit) will be provided with factory controls that will operate and maintain all aspects of this equipment (refer to the manufactures submittal package for all related details).

Ductless split system AC units shall be started and stopped through a space mounted electronic microcomputer-based room thermostat, by the equipment manufacture. The room thermostat (lockable cover) shall be capable of providing set-point adjustments and all programming control sequences. Each evaporator shall have a separate thermostat. Each evaporator's fan and compressors shall cycle to maintain room temperature set point 75° when indexed to the auto mode. All condenser, and compressor operations shall be controlled by the AC unit's built-in unitary controller. Provide a separate room temperature sensor provide by the BMS contractor for each evaporator. The sensor shall be report status, room high and low temperatures and enable alarms at the BMS workstation for unit failure, high and low temperatures, water detection.

As stated above, the manufacture supplied factory controls will operate and maintain all aspects of the equipment associated to each AC unit. We will provide all low voltage control and interlock wiring as well as the mounting and wiring of the associated factory supplied wall sensors.

The front-end web-based system will include a complete graphical representation of this control system and all its associated points, alarms, setpoints, schedules, sequences as detailed within this sequence and the HVAC Controls portion of the project plans, as well as what is required to make this system fully operational and user friendly.

2.8 AIR CONDITIONING CONDENSATE PUMPS

Provide connection to the overflow switch in each condensate pump tank arranged to annunciate an alarm at the BMS and shut down the respective AHU/AC unit if water is detected.

Provide a secondary high-level float switch in each packaged roof top unit condensate pan and each split system air handling unit condensate pan arranged to annunciate an alarm at the BMS and shut down the respective AHU/AC unit if water is detected.

2.9 Miscellaneous Plumbing Equipment: Provide Control Points (status/setpoints/alarms) for items noted below in sequence.

Domestic Hot Water Heater: When the domestic hot water heater calls for heat, the combustion air dampers will open, and the domestic hot water heater shall not operate until the dampers have been proven open via a damper end switch.

Domestic Hot Water Pump: The BMS system shall be arranged to operate the domestic hot water recirculation pump. The pump shall be operated based on return water temperature. When return water temperature drops below setpoint (110 deg F) the pump shall be started.

Domestic Hot Water Mixing valves: Domestic hot water mixing valves shall be 3-way mixing valves arranged to maintain the maintain domestic water to the building at 120°F maximum. The actual setpoint shall be 110°F. The second 3-way mixing valve shall be at the kitchen. This shall be arranged to maintain the domestic water to the pot sinks at 140°F maximum. In both cases there shall be secondary aqua stats on the respective hot water pipes arranged to close a solenoid valve in each of the hot water lines. Provide monitoring and set point adjustment at the BMS workstation. Alarm high temperature at the BMS.

Elevator pit sump pumps: provide an interface to the sump pump control panel. The panel alarm output shall be monitored and annunciated at the BMS. The oil minder pump control panel has a discriminating alarm output for oil detection.

2.10 Miscellaneous

All safety devices shall be interlocked with "hand" and "Automatic" positions in series with motor controller holding coil circuit. Interlocking with other fans and equipment of system shall be through "Automatic" position "Hand" position shall be for maintenance only. Remote starting shall be from through "automatic" position only.

For all AHU's, low limit thermostats (freeze-stats) shall de-energize supply fan is supply air temperature decreases below 38 degrees F (ADJUSTABLE). This shall alarm at BMS.

All air handling units 2,000 cfm or greater shall have a duct mounted smoke detector arranged to stop the unit and position all dampers and valves in the "unit off" sequence as described in this section, upon detecting smoke.

All air handling units, unit ventilators, cabinet unit heaters, unit heaters, fans, and fan coil units, shall be interlocked to the building fire alarm system. Upon building fire alarm all units shall shut down and damper and valves shall go to "unit off" positions.

END OF SECTION

SECTION 23 21 13

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. Dual Temp piping. (glycol)
 - 2. Makeup-water piping.
 - 3. Condensate-drain piping.
 - 4. Air-vent piping.
 - 5. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping materials.
 - 2. Pressure-seal fittings.
 - 3. Chemical treatment.
- 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.
 - 3. Environmental Product Declaration: For each product.
 - 4. Health Product Declaration: For each product.
 - 5. Sourcing of Raw Materials: Corporate sustainability report for each manufacturer.
- C. 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.
5. For underground piping provide size and quantity of pipe expansion loops and thrust blocks.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Piping layout, 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. Other building services.
 3. Structural members.
- B. Qualification Data: For Installer.
- C. Welding certificates.
- D. Field quality-control reports.
- E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
- B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

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. Dual Temp-Water Piping: 150 psig at 200 deg F.
 - 2. Glycol -Water Piping: 150 psig at 150 deg F.
 - 3. Makeup-Water Piping: 80 psig at 150 deg F.
 - 4. Condensate-Drain Piping: 150 deg F.
 - 5. Air-Vent Piping: 200 deg F.
 - 6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Anvil International.
 - b. Star Pipe Products.
 - c. Victaulic Company.
 - 2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
 - 3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, prelubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

2.3 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- H. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International.
 - b. Grinnell G-Fire by Johnson Controls Company.
 - c. Victaulic Company.
 - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
- I. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

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.

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. WATTS.
 - b. Wilkins.
 - c. Zurn Industries, LLC.
 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 150 psig 250 psig.
 - 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. WATTS.
 - b. Wilkins.
 - c. Zurn Industries, LLC.
 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 150 psig minimum at 250 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric Nipples:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Grinnell G-Fire by Johnson Controls Company.
 - b. Matco-Norca.
 - c. Victaulic Company.
2. Description:
 - a. Standard: IAPMO PS 66.
 - b. Electroplated steel nipple, complying with ASTM F 1545.
 - c. Pressure Rating: 300 psig at 225 deg F.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

2.6 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. Dual Temp-water, piping aboveground; NPS 2 1/2 and smaller, shall be any of the following:
 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed, pressure-seal joints.
 2. Schedule 40, Grade B, Type 96 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.
- B. Dual Temp-water, piping aboveground; NPS 3 and larger, shall be any of the following:
 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered, brazed joints.
 2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 3. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- C. Dual temp-water heating, piping below grounds and within slabs; shall be either of the following:
 1. Type K, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

- D. Makeup-water piping installed aboveground shall be either of the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- E. 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.
- F. Condensate-Drain Piping for AC Units: Type M copper, Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints .
- G. Air-Vent Piping:
 - 1. Inlet: Same as service were 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.
- H. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.2 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 Section 230523.101 " Valves for HVAC Piping," Section 230523.12
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install shutoff valve immediately upstream of each dielectric fitting.
- T. Comply with requirements in 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."
- X. For piping passing through equipment room walls to occupied spaces provide split seals for sound and vibration attenuation between rooms. Refer to section 232116.

3.3 DIELECTRIC FITTING INSTALLATION

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

- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

- A. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20' or the first two hangers. Refer to section 232112.13 Hydronic Piping specialties.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 6 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.
- D. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- E. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
- F. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

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

- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8/A5.8M.
- E. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. 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:
 - 1. pH: 9.0 to 10.5.
 - 2. "P" Alkalinity: 100 to 500 ppm.

3. Boron: 100 to 200 ppm.
4. Chemical Oxygen Demand: Maximum of 100 ppm. Revise this value if closed system contains glycol.
5. Corrosion Inhibitor:
 - a. Sodium Nitrate: 1000 to 1500 ppm.
 - b. Molybdate: 200 to 300 ppm.
 - c. Chromate: 200 to 300 ppm.
 - d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
 - e. Chromate Plus Molybdate: 50 to 100 ppm each.
6. Soluble Copper: Maximum of 0.20 ppm.
7. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum of 10 ppm.
8. Total Suspended Solids: Maximum of 10 ppm.
9. Ammonia: Maximum of 20 ppm.
10. Free Caustic Alkalinity: Maximum of 20 ppm.
11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maximum of 1000 organisms/mL.
 - b. Total Anaerobic Plate Count: Maximum of 100 organisms/mL.
 - c. Nitrate Reducers: 100 organisms/mL.
 - d. Sulfate Reducers: Maximum of zero organisms/mL.
 - e. Iron Bacteria: Maximum of zero organisms/mL.

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.

1. Fill systems that have antifreeze or glycol solutions with the following concentrations:
2. Dual Temp-Water Heating Piping: Minimum of 30% percent propylene glycol.

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

SECTION 232113.33

GROUND-LOOP HEAT-PUMP 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 piping for, direct-buried, ground-loop, heat-pump systems.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Pipe and fittings.
 - 2. Joining method and equipment.
 - 3. Propylene glycol solution.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Borehole backfilling and drilling operations reports.
- C. Dimensioned site layout.
- D. Startup performance results.

1.5 TEST WELL SUBMITTALS

- A. Product Data: Include construction materials, gauge, performance data, accessories, installation instructions, startup instructions, and furnished specialties as indicated.
- B. Shop Drawings: Provide shop drawings indicating the type of loop piping to be used, its physical characteristics, pipe wall thickness and materials of construction. Manufacturer of pipe shall be a firm regularly engaged in the production of geothermal loop heat exchanger products, or whose products have been satisfactorily used in similar services for not less than five years.

- C. Location plan for proposed test well for architect and engineers approval.
- D. Submit Formation Thermal conductivity test and Data analysis report. The report shall include the following:

Cover sheet:

Firm name
Address,
Phone #,
Email address,
Test location,
Date of test

Executive Summary:

Brief summary of test results
Formation thermal Conductivity (Btu/hr-ft-F)
Formation thermal Diffusivity (ft²/day)
Undisturbed soil temperature (+- 1 F)

Test procedure:

Include description of the test procedure. Test procedure shall follow recommendations set forth by the American Society of Heating, Refrigeration and Air-Conditioning (ASHRAE) and as published in the "2007 ASHRAE Handbook – HVAC Applications".

Data Analysis:

All relevant bore hole data including:

Bore hole size.
U-bend size
U-bend Type
Grout Type

Test data:

Test duration
Average voltage
Average power input
Total heat input rate
Circulated water flow rate.
Graph of time vs. temperature.

Test Results:

Estimated Heat capacity (Btuft³-F)
Thermal Conductivity (Btu/hr-ft-F)
Estimated Thermal Diffusivity (ft²/day)
Undisturbed Soil Temperature

PART 2 - PRODUCTS

2.1 PIPES 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. Centennial Plastics, Inc.
 - 2. Chevron-Phillips Chemical Company; Performance Pipe Division.
 - 3. Lamson Pipe Company.
- B. HDPE Pipe: ASTM D 3035.
- C. Molded PE Fittings: ASTM D 2683 or ASTM D 3261, ASTM F 1055 PE resin, socket, butt-fusion or electro-fusion type, made to match PE pipe dimensions and class.
- D. U-Bend Assembly: Factory fabricated with embossed depth stamp every 24 inches from U-bend.
- E. Ground-Loop, Heat-Pump Piping Minimum Working Pressure: 160 psig.
- F. Ground-Loop, Heat-Pump Piping Operating Temperature: Between 23 and 104 deg F.

2.2 HEAT EXCHANGER

- A. The Geothermal Loop Heat Exchanger consist of polyethylene piping, fusion joined into vertical loops and connected with horizontal headers. The Geothermal Loop Heat Exchanger work end at manifolds as indicated on drawings. The headers will be located on the job by the Engineer and owner's representative, after consulting with the Contractor installing the Geothermal Loop Heat Exchanger.
 - 1. The vertical Geothermal Loop Heat Exchangers (GLHE's) shall be constructed of high-density polyethylene pipe, SDR-11. It must conform to the Material Physical Property, testing, Certification and Listing Specifications identified in Section A. "Piping." Each GLHE shall be closed by means of a single- or double-elbow style U-bend at the bottom of the loop. The U-bend shall be constructed and attached to the GLHE using the heat fusion bonding method.
 - 2. The GLHE shall be pressure tested before insertion into the borehole and again after manifolding. Testing shall be by air or water, at up to 100-psi minimum or 1.5 times the actual operating pressure for a minimum of 30 minutes. Exercise suitable safety precautions during testing, to guard against injury to personnel near lines being tested, in case of pipe system component, or joint failure under pressure. Results of all tests shall be recorded and supplied to the Engineer upon completion of the Project, or as required by the Engineer.
 - 3. After insertion into the borehole, the GLHE shall be flushed with water until the exiting water runs clear.

B. Grouting

1. the vertical GLHE bore holes shall be grouted completely with bentonite clay grout or an engineered thermal grout with a conductivity of 1.2 BTU F., and in conformance with the International Ground Source Heat Pump Association's (IGSIIPA) standards specified in their publication "Proper Grouting Procedures for Ground Source Heat Pump System," and all State and Local requirements. Since settling of grouting material will occur after the initial grouting, Contractor shall monitor each bore hole and continue adding grout as required. Meet or exceed grout specification of test well.

2.3 BOREHOLE BACKFILL

- A. Seal Material: Bentonite clay with thermal conductivity greater than 1.07 Btu/h x sq. ft. x deg F according to ASTM D 5334.
- B. Permeability: Not more than 1 nm/s according to ASTM D 5084

2.4 ANTIFREEZE SOLUTION

- A. Propylene Glycol: Minimum 99 percent propylene glycol with corrosion inhibitors and environmental stabilizer additives to be mixed with water to protect piping circuit and connected equipment from physical damage caused by freezing or corrosion.
- B. Quantity: Sufficient solution for initial system startup and for preventive maintenance for one year from date of Substantial Completion.
- C. Dilution Water: Chloride content shall be less than 25 ppm, sulfate content less than 25 ppm, and hardness less than 100 ppm.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Excavating, trenching, warning tape, and backfilling are specified in Section 312000 "Earth Moving."

3.2 WELL INSTALLATION

- A. Wells for geothermal heat pump applications shall be drilled to a depth as indicated on plans.
- B. The minimum well diameter shall be 5".

- C. The well driller shall maintain a well log for the bores, which shall include a record of the drilling rate, equipment and type of drill rig used, depth(s) at which water is found, and water quality analysis. The water quality analysis shall identify potability of water and level of brackishness. The log shall indicate where bedrock is found, and other anomalies in the soil or rock layers, such as salt beds, aquifers or methane pockets.
- D. A record of the well production and recovery shall be kept, in gallons per minute.
- E. The drilling contractor shall fabricate high density polyethylene piping, SDR-11 with a U-bend at one end. Splices in the piping shall be formed using heat fusion joints. The assembly shall be pressure tested to 100 psi for 30 minutes. The piping u-tube assembly shall be equipped with "geo-clips" to anchor the pipe in position, and inserted into the bore hole, to the bottom, and the bore hole grouted to the top.
- F. Grouting material shall be a slurry of "thermal grout", a 20% solids mixture of bentonite and silicon sand. Grout shall be introduced into the bore hole at the bottom and filled to the top. The type of grout and its characteristics shall be recorded.
- G. TEST WELL - Once the loop is installed, the drilling contractor shall perform a thermal conductivity test on the well. Thermal conductivity test shall be performed for a period not less than 48 hours, and a record kept of the heat transfer rate achieved. The thermal conductivity of the formations shall be calculated and recorded, as well as the formation thermal diffusivity. The contractor shall provide all on site power as required to run test apparatus for test duration.
- H. TEST WELL - Water shall be circulated through the u-pipe in a closed loop circuit. A heat load shall be introduced on the circulating water and a record kept of the flow in GPM, the pressure drop through the pipe, the change in temperature of the supply and return water streams and a calculation performed to determine the thermal conductivity in BTU/hr per foot of bore hole. A detailed report of the thermal conductivity test and formation diffusivity shall be provided to the engineer.
- I. TEST WELL - Power Quality – The standard deviation of input power should be less than +/- 1.5% of the average value and peaks less than +/- 10% of average, or resulting temperature variation should be less than +/- 0.5 degrees F from a straight trend line of a log (time) versus average loop temperature. The heat rate should be 15 to 25 watts (51 to 85 Btu/hr) per foot of bore to best simulate the expected peak loads on the U-bends for an actual heat pump system.
- J. TEST WELL - Undisturbed Soil Temperature Measurement – The undisturbed soil temperature should be determined by recording the minimum loop temperature as the water returns from the U-bend at test start-up.
- K. TEST WELL - Time Between Loop Installation and Testing – A waiting period of five days is suggested for low conductivity soils ($k < 1.0$ Btu/hr-ft-F) after the ground loop has been installed and grouted before the thermal conductivity test is initiated. A delay of three days is recommended for higher conductivity formations ($k > 1.0$ Btu/hr-ft-F)

3.3 HORIZONTAL PIPING INSTALLATION

- A. Separate trenches by 10 feet minimum unless otherwise indicated. Remove rocks in trenches that could contact pipe.
- B. Backfill
- C. Extend pipe from trench onto bottom of body of water at an elevation that is at least 12 inches below frost line. Seal membrane or impervious liner under body of water after installing piping.
- D. Install HDPE piping in trenches according to ASTM D 2774 or ASTM F 645.
 - 1. Clean HDPE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
- E. Purge, flush, and pressure test piping before backfilling trenches.
- F. Install continuous detectable warning tape for underground piping. Locate tape a minimum of 24 inches below finished grade, directly over piping. Underground warning tapes are specified in Section 312000 "Earth Moving."

3.4 VERTICAL PIPING INSTALLATION

- A. Install HDPE piping in boreholes according to ASTM D 2774 or ASTM F 645.
 - 1. Clean HDPE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
- B. Purge, flush, and pressure test piping before backfilling boreholes.
- C. Completely fill the borehole from bottom to top with backfill material.
- D. Install the header piping 4 to 6 inches deep and install the horizontal piping from the header to the boreholes.
- E. Extend the horizontal piping and connect to ground-loop heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.
 - 1. Terminate water-service piping at building wall until building ground-loop heat-pump piping systems are installed. Terminate piping with caps. Make connections to building ground-loop heat-pump piping systems when those systems are installed.
- F. Backfill the horizontal piping and header trenches.
- G. Fill the entire piping loop with water or antifreeze solution.
- H. Maintain records of backfilling on-site.

- I. Mark borehole locations, header pipes, and horizontal runs with metallic locator tape as specified in Section 230553 "Identification for HVAC Piping and Equipment."
- J. Seal penetrations through building walls.
- K. Wall sleeves are specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- L. Mechanical sleeve seals are specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

3.5 ANTIFREEZE SOLUTION FILL

- A. Fill system with required quantity of propylene glycol and water to provide minus 10 deg F freezing temperature.
- B. Test dilute solution using gas chromatography to verify concentration of propylene glycol, and forward report to Architect.

3.6 SITE RESTORATION

- A. TEST WELL - Upon completion of the test well and thermal conductivity test, the well casing and tubing shall be capped at a level not exceeding 24" above grade.
- B. The site shall be restored to condition suitable for final grading. Where applicable replace sod, ruts filled in, and grass seed and straw distributed over any disturbed lawn area. Compaction shall be such that is receptive to parking lot installation post final acceptance of geothermal well field installation

3.7 CONNECTIONS

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

3.8 FIELD QUALITY CONTROL

- A. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.
- B. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating or 300 percent of system design pressure, whichever is more, allowing for static pressure of borehole depth.
 - 1. Increase pressure in 50-psig increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig. Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.

2. Maintain a minimum pipe velocity of 24 in./s for a minimum of 15 minutes to remove all air.
- C. Prepare test and inspection reports.

END OF SECTION

SECTION 23 21 16
HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes special-duty valves and specialties for the following:

1. Dual Temp-water piping.
2. Makeup-water piping.
3. Condensate-drain piping.
4. Blowdown-drain piping.
5. Air-vent piping.
6. Safety-valve-inlet and -outlet piping.
7. Vibration Isolation
8. Expansion fittings for hydronic piping
9. Pipe guides and anchors

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:

1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
2. Air-control devices.
3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: 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 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
 - 1. Dual Temp Water Heating Piping: 150 psig at 200 deg F
 - 2. Makeup-Water Piping: 80 psig at 150 deg F
 - 3. Condensate-Drain Piping: 150 deg F.
 - 4. Blowdown-Drain Piping: 200 deg F
 - 5. Air-Vent Piping: 200 deg F.
 - 6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

- A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523.10 "Valves for HVAC Piping,"
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230923.11 "Control Valves."Section 15901 "Control Valves."

2.3 Bronze, Calibrated-Orifice, Balancing Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. Nexus Valve, Inc.
 - d. TACO Comfort Solutions, Inc.
 - e. Tour & Andersson; available through Victaulic Company.
 - f. Victaulic Company.
- 2. Body: Bronze, ball or globe type with calibrated orifice or venturi.
- 3. Ball: Brass or stainless steel.
- 4. Seat: PTFE.
- 5. End Connections: Threaded or socket.

6. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 7. Handle Style: Lever, with memory stop to retain set position.
 8. CWP Rating: Minimum 125 psig
 9. Maximum Operating Temperature: 250 deg F
- B. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett; a Xylem brand.
 - c. Nexus Valve, Inc.
 - d. Tour & Andersson; available through Victaulic Company.
 2. Body: Cast-iron or steel body, 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, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett; a Xylem brand.
 - d. Spence Engineering Company, Inc.
 - e. Watts; a Watts Water Technologies 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, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett; a Xylem brand.
 - d. Spence Engineering Company, Inc.
 - e. Watts; a Watts Water Technologies 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, provide products by one of the following:
 - a. Flow Design, Inc.
 - b. Griswold Controls.
 - c. Nexus Valve, Inc.
 - d. NuTech Hydronic Specialty Products.
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, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig
9. Maximum Operating Temperature: 200 deg F

2.4 AIR-CONTROL DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- a. AMTROL, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett; a Xylem brand.
 - d. TACO Comfort Solutions, Inc.
 - e. John Wood

- B. Manual Air Vents:
 - 1. Body: Bronze.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Screwdriver or thumbscrew.
 - 4. Inlet Connection: NPS 1/2
 - 5. Discharge Connection: NPS 1/8.
 - 6. CWP Rating: 150 psig
 - 7. Maximum Operating Temperature: 225 deg F
- C. Automatic Air Vents:
 - 1. Body: Bronze or cast iron.
 - 2. Internal Parts: Nonferrous.
 - 3. Operator: Noncorrosive metal float.
 - 4. Inlet Connection: NPS 1/2
 - 5. Discharge Connection: NPS 1/4
 - 6. CWP Rating: 150 psig
 - 7. Maximum Operating Temperature: 240 deg F
- D. Expansion Tanks:
 - 1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature, with taps in bottom of tank for tank fitting and taps in end of tank for gage glass. Tanks shall be factory tested after taps are fabricated and shall be labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Air-Control Tank Fitting: Cast-iron body, copper-plated tube, brass vent tube plug, and stainless-steel ball check, 100-gal. unit only; sized for compression-tank diameter. Provide tank fittings for 125-psig working pressure and 250 deg F maximum operating temperature.
 - 3. Tank Drain Fitting: Brass body, nonferrous internal parts; 125-psig working pressure and 240 deg F maximum operating temperature; constructed to admit air to compression tank, drain water, and close off system.
 - 4. Gage Glass: Full height with dual manual shutoff valves, 3/4-inch- diameter gage glass, and slotted-metal glass guard.
- E. Diaphragm or Bladder-Type Expansion Tanks as scheduled or noted on plans:
 - 1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test after taps is fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 - 3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
- F. Tangential-Type Air Separators:
 - 1. Tank: Welded steel; ASME constructed and labeled for 125-psig minimum working pressure and 375 deg F maximum operating temperature.
 - 2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
 - 3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 and smaller; flanged connections for NPS 2-1/2 and larger.
 - 4. Blowdown Connection: Threaded.

5. Size: Match system flow capacity.

G. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig
3. Maximum Operating Temperature: Up to 300 deg F

H. Air Purgers:

1. 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.
2. Maximum Working Pressure: 150 psig
3. Maximum Operating Temperature: 250 deg F

2.5 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: Stainless-steel, 20-mesh strainer, or perforated stainless-steel basket.
4. CWP Rating: 125 psig

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig

D. 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

E. Spherical, Rubber, Flexible Connectors:

1. Rubber flexible connections shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.
2. Minimum ratings shall be 250 psi at 170°F and 215 psi at 250°F. Higher published rated connectors may be used where required.
3. Safety factors shall be a minimum of 3/1. All flexible connections must be factory tested to 150% of maximum pressure for 12 minutes before shipment. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them.
4. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc
 - a. Body: Fiber-reinforced rubber body.
 - b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 - c. Performance: Capable of misalignment.
 - d. CWP Rating: 150 psig
 - e. Maximum Operating Temperature: 250 deg F

F. Braided Pipe Flexible Connection:

1. Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes may have male nipples. Minimum sizes listed below.

Flanged (Pipe Dia x Flexible Pipe Length)		
3" x 12"	6" x 18"	12" x 24"
4" x 12"	8" x 18"	14" x 30"
5" x 18"	10" x 18"	16" x 32"

Male Nipples (Pipe Dia x Flexible Pipe Length)		
1/2" x 12"	1-1/4" x 12"	2" x 12"
3/4" x 12"	1-1/2" x 12"	2-1/2" x 18"
1" x 12"		

2. At equipment connections, hoses shall be installed on the equipment side of the shut-off valves horizontal and parallel to the equipment shafts wherever possible. Hoses shall be type FFL or type MN as manufactured by Mason Industries, Inc
- G. Vibration isolation pipe hangers: pre-compressed and locked at the rated deflection by means of a resilient up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc
- H. Acoustic Split Seals: consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Grout seals to make it integral with the floor, wall, or ceiling in masonry construction. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

2.6 PACKLESS EXPANSION JOINTS

- A. Metal, Compensator Packless Expansion Joints: Metraflex Model HPFF – for copper, Model HP for steel pipe
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flexicraft Industries.
 - b. Mason Industries, Inc.
 - c. Metraflex Company (The).
 2. Minimum Pressure Rating: 175 psig unless otherwise indicated.
 3. Description: Totally enclosed, externally pressurized, multi-ply bellows isolated from fluid flow by an internal pipe sleeve and external housing.
 4. Joint Axial Movement: 2 inches of compression and 1/2 inch of extension.
 5. Configuration for Copper Tubing: Multi-ply, phosphor-bronze bellows with copper pipe ends.
 - a. End Connections for Copper Tubing NPS 2 and Smaller: Solder joint or threaded.
 - b. End Connections for Copper Tubing NPS 2-1/2 to NPS 4: Threaded.
 6. Configuration for Steel Piping: Multi-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
 - a. End Connections for Steel Pipe NPS 2 and Smaller: Threaded.
 - b. End Connections for Steel Pipe NPS 2-1/2 to NPS 4: Threaded Welded.

2.7 GROOVED-JOINT EXPANSION JOINTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Anvil International.
 - 2. Grinnell G-Fire by Johnson Controls Company.
 - 3. Victaulic Company.
- B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- C. Standard: AWWA C606, for grooved joints.
- D. Nipples: ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- E. Couplings: flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water, and bolts and nuts.

2.8 ALIGNMENT GUIDES AND ANCHORS

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advanced Thermal Systems, Inc.
 - b. Flexicraft Industries.
 - c. Mason Industries, Inc.
 - d. Metraflex Company (The).
- 2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding slider for bolting to pipe.
- 3. Steel Shapes and Plates: ASTM A 36/A 36M.
- 4. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
- 5. Washers: ASTM F 844, steel, plain, flat washers.
- 6. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened concrete, with tension and shear capacities appropriate for application. Threaded stud, expansion plug, nuts and washers shall be zinc-coated carbon steel.
- 7. Chemical Fasteners: Insert-type stud, bonding-system anchor for use with hardened concrete, with tension and shear capacities appropriate for application.
 - a. Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
 - b. Stud: threaded stud washers and nuts shall be ASTM A 307, zinc-coated carbon steel.

- c. Alignment Guides
 - 1) Horizontal split spider type guide – Metraflex – Style IV
 - 2) Slide guide - – Metraflex – model PTFE.
 - 3) Pre-insulated guide – Metraflex – model PG PRE
 - 4) Vertical glide riser - – Metraflex – model PGQ
- d. Anchors
 - 1) Anchor clamp – Metraflex – model PA
 - 2) Structural I Beam Anchors – Metraflex
 - 3) Pre-insulated Anchor – Metraflex – model PAPI
 - 4) Modular riser guide – Metraflex – modular riser with EPDM insert.

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.
- G. All valves and specialties installed in the system shall have a pressure rating that exceeds the system working pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. All valves and specialties installed in the system shall have a pressure rating that exceeds the system working pressure.
- B. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- C. 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.

- D. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- E. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- F. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- G. Install steel braided flexible pipe connections at all coil connections and at all piping connections to motor driven equipment.
- H. Isolate piping from base mounted pumps with spherical rubber flexible connections
- I. Install vibration isolation hangers or supports on all piping connected to motor driven equipment for a distance of 20' or the first two hangers.
- J. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.
 - 1. Install tank fittings that are shipped loose.
 - 2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.
- K. 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. System pressure shall be 5 psi minimum residual at the top of the system.
- L. Install Acoustic split seals on all hydronic piping 2" and over, penetrating mechanical equipment room walls.
- M. Install Packless expansion fittings in all hydronic pipe sections, regardless of service, that is over 75' long straight run. Alternative pipe "expansion loop" may be used if space permits. Piping layout submittal shall indicate guide and ridged mount locations.

3.3 EXPANSION JOINT INSTALLATION

- A. Install expansion joints of sizes matching sizes of piping in which they are installed.
- B. Install grooved-joint expansion joints to grooved-end steel piping.
- C. Grooved end pipe applications can use multiple grooved coupling installed in an arrangement as approved by the manufacture for the specific application. The manufacture shall recommend the number, placement, and arrangement in the piping systems. Submit to the engineer for review and approval.

3.4 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

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

3.5 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install one guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint or loop not more than three pipe diameters from expansion joint.
- C. Attach guides to pipe, and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24; U bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 23 21 23
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.
 - 2. Close-coupled, base mounted end-suction centrifugal pumps.
 - 3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
 - 4. Separately coupled, vertically mounted, in-line centrifugal pumps.
 - 5. Separately coupled, base-mounted, end-suction centrifugal pumps.
 - 6. Automatic condensate pump units.

1.3 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.4 ACTION 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.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong Pumps, Inc.
 - 2. ITT Corporation.
 - 3. Mepco, LLC.
 - 4. PACO Pumps; Grundfos Pumps Corporation, USA.
 - 5. Patterson Pump Company; a Gorman-Rupp company.
 - 6. Peerless Pump Company.
 - 7. TACO Comfort Solutions, Inc.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 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, replaceable bronze wear rings, and threaded or companion-flange connections.
 - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 - 3. Pump Shaft: stainless steel
 - 4. Motor shaft; carbon steel.
 - 1. 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.
 - 2. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

3. Pump Bearings: Oil lubricated; bronze-journal or thrust type.
- 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: Open, drip proof.
 - b. Enclosure Materials: Cast iron Rolled steel.
 - c. Motor Bearings: Permanently lubricated ball bearings up through 5 HP
 - d. Motor Bearings Grease lubricated ball bearings over 5 HP.
 - e. Unusual Service Conditions:
 - 1) Ambient Temperature: 40 deg C 104 F.
 - 2) Altitude: 100 feet above sea level.
 - 3) High humidity.
 - f. Efficiency: Premium efficient.
 - g. NEMA Design: B or C
 - h. Service Factor: 1.15.
 - i. All motors used with VFDs shall be inverter duty rated
- E. Capacities and Characteristics: Refer to plans and schedules.
- F. Electrical Characteristics: Refer to plans and schedules.
- 2.2 CLOSE-COUPLED, BASED MOUNTED END-SUCTION CENTRIFUGAL PUMPS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps, Inc.
 2. Aurora Pump; Pentair Ltd.
 3. Buffalo Pumps, Inc.
 4. ITT Corporation Bell and Gossett.
 5. Mepco, LLC.
 6. PACO Pumps; Grundfos Pumps Corporation, USA.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and flanged connections.
 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 3. Shaft: Carbon steel.
 4. Shaft sleeve; brass or stainless steel
 5. Mechanical Seal: 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.
 6. Pump Bearings: Permanently lubricated ball bearings.
- D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.
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: Open, drip proof Totally enclosed, or fan cooled.
 - b. Enclosure Materials: Cast iron or Rolled steel.
 - c. Motor Bearings: Permanently lubricated ball bearings up through 5HP
 - d. Motor Bearings Grease lubricated over 5HP.
 - e. Unusual Service Conditions:
 - 1) Ambient Temperature: 40 deg C 104 F.
 - 2) Altitude: 100 feet above sea level.
 - 3) High humidity.
 - f. Efficiency: Premium efficient.
 - g. NEMA Design: B or C.
 - h. Service Factor: 1.15.
 - i. All motors used with VFDs shall be inverter duty rated
- E. Capacities and Characteristics: Refer to plans and schedules.
- F. Electrical Characteristics: Refer to plans and schedules.
- 2.3 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps, Inc.
 2. ITT Corporation Bell and Gossett.
 3. Mepco, LLC.

4. PACO Pumps; Grundfos Pumps Corporation, USA.
 5. Peerless Pump Company.
 6. TACO Comfort Solutions, Inc.
 7. Thrush Co. Inc.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.
- 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 or brass; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
 3. Pump Shaft: Carbon Steel
 4. Sleeve; Alloy Copper 110.
 5. Mechanical Seal: 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.)
 6. Pump Bearings: permanently Oil lubricated; bronze-journal or thrust type.
- D. Shaft Coupling: Molded rubber insert with interlocking spider capable of absorbing vibration.
- E. 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: Open, drip proof or Totally enclosed, fan cooled.
 - b. Enclosure Materials: Cast iron or Rolled steel.
 - c. Motor Bearings: Permanently lubricated ball bearings. Up to 5 hp
 - d. Motor Bearings: Grease-lubricated ball bearings. Over 5 hp
 - e. Unusual Service Conditions:
 - 1) Ambient Temperature: 40 deg C 104 F.
 - 2) Altitude: 100 feet above sea level.
 - 3) High humidity.
 - f. Efficiency: Premium efficient.
 - g. NEMA Design: B or C
 - h. Service Factor: 1.15.
 - i. All motors used with VFDs shall be inverter duty rated
- F. Capacities and Characteristics: Refer to plans and schedules.

- G. Electrical Characteristics: Refer to plans and schedules.

2.4 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps, Inc.
2. ITT Corporation.
3. Mepco, LLC.
4. PACO Pumps; Grundfos Pumps Corporation, USA.
5. Patterson Pump Company; a Gorman-Rupp company.
6. Peerless Pump Company.
7. TACO Comfort Solutions, Inc.

- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

- C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange or union-end connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
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. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Permanently lubricated ball bearings.

- D. Shaft Coupling: Axially split spacer coupling.

- E. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

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: Open, drip proof or Totally enclosed, fan cooled.

- b. Enclosure Materials: Cast iron or Rolled steel.
- c. Motor Bearings: Permanently lubricated ball bearing up to 5 hp
- d. Motor Bearings Grease-lubricated ball bearings over 5 hp.
- e. Unusual Service Conditions:
 - 1) Ambient Temperature: 40 deg C 104 F.
 - 2) Altitude: 100 above sea level.
 - 3) High humidity.
- f. Efficiency: Premium efficient.
- g. NEMA Design: B or C
- h. Service Factor: 1.15.
- i. All motors used with VFDs shall be inverter duty rated.

F. Capacities and Characteristics: Refer to plans and schedules.

G. Electrical Characteristics: Refer to plans and schedules.

2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

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

- 1. Armstrong Pumps, Inc.
- 2. ITT Corporation.
- 3. Mepco, LLC.
- 4. PACO Pumps; Grundfos Pumps Corporation, USA.
- 5. Patterson Pump Company; a Gorman-Rupp company.
- 6. Peerless Pump Company.
- 7. TACO Comfort Solutions, Inc.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

- 1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and threaded companion-flange, flanged connections. Provide integral mount on volute to support the casing and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.
- 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
- 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.

5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
 6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.
- D. Shaft Coupling: Molded rubber insert and interlocking spider capable of absorbing vibration. Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor. EPDM coupling sleeve for variable-speed applications.
- E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.
- F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.
- G. Motor: Single speed, secured to mounting frame, with adjustable alignment.
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: Open, drip proof or Totally enclosed, fan cooled.
 - b. Enclosure Materials: Cast iron or Rolled steel.
 - c. Motor Bearings: Permanently lubricated or Grease-lubricated ball bearings.
 - d. Unusual Service Conditions:
 - 1) Ambient Temperature: 40 deg C 104 F.
 - 2) Altitude: 100 above sea level.
 - 3) High humidity.
 - e. Efficiency: Premium efficient.
 - f. NEMA Design: B or C
 - g. Service Factor: 1.15.
 - h. All motors used with VFDs shall be inverter duty rated.
- H. Capacities and Characteristics: Refer to plans and schedules.
- I. Electrical Characteristics: Refer to plans and schedules.
- 2.6 AUTOMATIC CONDENSATE PUMP UNITS
- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Little Giant
2. Armstrong Pumps, Inc.
3. ITT Corporation.
4. Mepco, LLC.
5. PACO Pumps; Grundfos Pumps Corporation, USA.
6. Patterson Pump Company; a Gorman-Rupp company.
7. Peerless Pump Company.
8. TACO Comfort Solutions, Inc.

- B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug.
- C. Capacities and Characteristics: Refer to plans and schedules.
- D. Electrical Characteristics: Refer to plans and schedules.

2.7 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

B. Triple-Duty Valve:

1. Angle or straight pattern.
2. 175-psig pressure rating, ductile-iron body, pump-discharge fitting.
3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
4. Brass gage ports with integral check valve and orifice for flow measurement.

C. Flexible Pipe/Pump Connections:

1. Rubber flexible connections shall be peroxide cured EPDM throughout with Kevlar tire cord reinforcement. The raised face rubber flanges must encase solid steel rings to prevent pull out. Flexible cable wire is not acceptable. Sizes 1-1/2" through 14" shall have a ductile iron external ring between the two spheres. Sizes 3/4" through 2" may have one sphere, bolted threaded flange assemblies and cable retention.
2. Minimum ratings shall be 250 psi at 170°F and 215 psi at 250°F. Higher published rated connectors may be used where required.
3. Safety factors shall be a minimum of 3/1. All flexible connections must be factory tested to 150% of maximum pressure for 12 minutes before shipment. The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2" thick Neoprene washer bushings large enough to take the thrust at 1000psi of surface area may be used on unanchored piping where

the manufacturer determines the condition exceeds the expansion joint rating without them. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc

4. All flexible joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc
 - a. Body: Fiber-reinforced rubber body.
 - b. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
 - c. Performance: Capable of misalignment.
 - d. CWP Rating: 150 psig
 - e. Maximum Operating Temperature: 250 deg F

2.8 VIBRATION ISOLATION AND INERTIA BASES FOR PUMPS

- A. Rectangular steel concrete pouring forms for floating concrete inertia base. Bases for split case pumps shall be large enough to provide support for suction and discharge elbows. Bases shall be a minimum of 6" longer than the pump on all sides. The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include concrete reinforcing bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Minimum reinforcing bar size shall be 1/2". Forms shall be furnished with steel templates to hold the anchor bolt sleeves and anchor bolts while concrete is being poured. Height saving spring brackets shall be used in all mounting locations to maintain a 1" clearance below the base. Wooden formed bases leaving a concrete are not acceptable. Base shall be type BMK as manufactured by Mason Industries, Inc

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 ANSI standard HI 1.4 and HI 2.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to discharge indirectly to an open drain.
- E. Equipment Mounting:
 - 1. Install base-mounted pumps on cast-in-place concrete housekeeping pads. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." and Section 033053 "Miscellaneous Cast-in-Place Concrete." Concrete housekeeping pads shall be 3 ½" high and extend 6" longer on all sides than the mountings and shall have 45° chamfered edges.
 - a. Pumps shall be mounted on spring isolation inertia bases.
 - 2. Install in-line pumps with continuous-thread hanger rods and elastomeric hangers, spring hangers, spring hangers with vertical-limit stop of size required to support weight of in-line pumps as per specification section 23 21 16 Hydronic Piping Specialties.

3.3 ALIGNMENT

- A. Perform pump alignment. For pumps 20 HP or larger engage a factory-authorized service representative to perform alignment service.
- B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.
- C. Comply with pump and coupling manufacturers' written instructions.
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

- A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to 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 line size check, shutoff, and balancing valves or triple-duty valve on discharge side of pumps.
- F. Install line size Y-type strainer or suction diffuser and shutoff valve on suction side of pumps.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping or install single gage with multiple-input selector valve.
- I. Install check valve and gate or ball valve on each condensate pump unit discharge.
- J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

- A. Perform the following startup service; For motors 20 HP and over engage a factory-authorized service representative to perform the start up.
 - 1. Complete installation and startup check according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.6 DEMONSTRATION

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

END OF SECTION

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Refrigerant pipes and fittings.
 - 2. Refrigerant piping valves and specialties.
 - 3. Refrigerants.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
 - 1. Include pressure drop, based on manufacturer's test data, for the following:
 - a. Thermostatic expansion valves.
 - b. Solenoid valves.
 - c. Hot-gas bypass valves.
 - d. Filter dryers.
 - e. Strainers.
 - f. Pressure-regulating valves.
- B. Sustainable Design Submittals:
 - 1. Product Data for EA Prerequisite "Fundamental Refrigerant Management": For refrigerants, indicating compliance with refrigerant management practices.
- C. Shop Drawings:
 - 1. Show piping size and piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
 - 2. Show interface and spatial relationships between piping and equipment.
 - 3. Shop Drawing Scale: 1/4 inch equals 1 foot.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.
- B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.6 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to 2010 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.7 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 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-134a:
 - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
 - 2. Suction Lines for Heat-Pump Applications: 225 psig.
 - 3. Hot-Gas and Liquid Lines: 225 psig.
- B. Line Test Pressure for Refrigerant R-407C:
 - 1. Suction Lines for Air-Conditioning Applications: 230 psig.
 - 2. Suction Lines for Heat-Pump Applications: 380 psig.
 - 3. Hot-Gas and Liquid Lines: 380 psig.
- C. 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.

2.2 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 88, Type L – Refer to section 3 for applications.
- B. ASTM B 280, Type ACR. – Refer to section 3 for applications
- C. Wrought-Copper Fittings: ASME B16.22.
- D. Wrought-Copper Unions: ASME B16.22.
- E. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- F. Brazing Filler Metals: AWS A5.8/A5.8M.
- G. 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.
- H. Flexible Connectors:
 - 1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket.
 - 2. End Connections:
 - a. NPS 2 and Smaller: With threaded-end connections.
 - b. NPS 2-1/2 and Larger: With flanged-end connections.
 - 3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch-long assembly.
 - 4. Pressure Rating: Factory test at minimum 500 psig.
 - 5. Maximum Operating Temperature: 250 deg F.

2.3 VALVES AND SPECIALTIES

- A. Manufactures:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Danfoss Inc.
 - b. Heldon Products; Henry Technologies.
 - c. Paul Mueller Company.
 - d. Danfoss Inc.

- e. Parker Hannifin Corp.
- f. Keep-Rite Co.

B. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

C. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

D. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

E. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

F. Solenoid Valves: Comply with AHRI 760 and UL 429; listed and labeled by a National Recognized Testing Laboratory (NRTL).

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24-V ac coil.

6. Working Pressure Rating: 400 psig.
 7. Maximum Operating Temperature: 240 deg F.
- G. Safety Relief Valves: Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Seat: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Working Pressure Rating: 400 psig.
 6. Maximum Operating Temperature: 240 deg F.
- H. Thermostatic Expansion Valves: Comply with AHRI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 5. Suction Temperature: 40 deg F.
 6. Superheat: Adjustable or Nonadjustable.
 7. Reverse-flow option (for heat-pump applications).
 8. End Connections: Socket, flare, or threaded union.
 9. Working Pressure Rating: 700 psig.
- I. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.
1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
 5. Seat: Polytetrafluoroethylene.
 6. Equalizer: Internal or External.
 7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter and 24-V ac coil.
 8. End Connections: Socket.
 9. Throttling Range: Maximum 5 psig.
 10. Working Pressure Rating: 500 psig.
 11. Maximum Operating Temperature: 240 deg F.
- J. Straight-Type Strainers:
1. Body: Brass or welded steel with corrosion-resistant coating.
 2. Screen: 100-mesh stainless steel.
 3. End Connections: Socket or flare.
 4. Working Pressure Rating: 500 psig.
 5. Maximum Operating Temperature: 275 deg F.
- K. Angle-Type Strainers:
1. Body: Forged brass or cast bronze.
 2. Drain Plug: Brass hex plug.
 3. Screen: 100-mesh monel.
 4. End Connections: Socket or flare.

5. Working Pressure Rating: 500 psig.
 6. Maximum Operating Temperature: 275 deg F.
- L. Moisture/Liquid Indicators:
1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in parts per million (ppm).
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.
 6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 240 deg F.
- M. Replaceable-Core Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina or charcoal.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig.
 8. Rated Flow: .
 9. Working Pressure Rating: 500 psig.
 10. Maximum Operating Temperature: 240 deg F.
- N. Permanent Filter Dryers: Comply with AHRI 730.
1. Body and Cover: Painted-steel shell.
 2. Filter Media: 10 microns, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina or charcoal.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 7. Maximum Pressure Loss: 2 psig.
 8. Rated Flow
 9. Working Pressure Rating: 500 psig.
 10. Maximum Operating Temperature: 240 deg F.
- O. Mufflers:
1. Body: Welded steel with corrosion-resistant coating.
 2. End Connections: Socket or flare.
 3. Working Pressure Rating: 500 psig.
 4. Maximum Operating Temperature: 275 deg F.
- P. Receivers: Comply with AHRI 495.
1. Comply with 2010 ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 2. Comply with UL 207; listed and labeled by an NRTL.
 3. Body: Welded steel with corrosion-resistant coating.

4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

Q. Liquid Accumulators: Comply with AHRI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

R. FLEXIBLE CONNECTORS

1. Corrugated stainless steel bronze hose with single layer of stainless-steel exterior braiding, minimum 6 inches long with copper tube ends; for maximum working pressure 500 psi.

2.4 REFRIGERANTS

- A. ASHRAE 34, R-134a: Tetrafluoroethane.
- B. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.
- C. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT:

- A. Suction Lines NPS 1-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed or soldered joints.
- C. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints or Type K or Type L, drawn-temper tubing, and wrought-copper fittings with soldered joints.
 1. NPS 1-1/2 and Smaller: Copper, Type L, drawn-temper tubing, and wrought-copper fittings with soldered joints.

3.2 VALVE AND SPECIALTY APPLICATIONS

- A. Install diaphragm packless valves in suction and discharge lines of compressor.

- B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- D. Except as otherwise indicated, install diaphragm packless or packed-angle valves on inlet and outlet side of filter dryers.
- E. Install a full-size, three-valve bypass around filter dryers.
- F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.
- G. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- H. Install safety relief valves where required by 2010 ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for the device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
- L. Install receivers sized to accommodate pump-down charge.
- M. Install flexible connectors at compressors.

3.3 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings.

- B. Install refrigerant piping according to ASHRAE 15 and in accordance the unit manufactures guidelines. Maintain refrigerant velocities within manufactures recommendations to keep oil entrained.
- 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 Section 230993.11 "Sequence of Operations for HVAC DDC" 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."
- V. Install refrigerant piping to allow expansion and contraction of piping without deformation or bending or sagging. Provide expansion fittings, bends or elbows to allow expansion in accordance with manufactures temperature operating range.

3.4 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.
- F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and to restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- H. Welded Joints: Construct joints according to AWS D10.12M/D10.12.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 HANGERS AND SUPPORTS

- A. 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.
- D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 2: Maximum span, 10 feet; minimum rod, 3/8 inch.
 - 2. NPS 2-1/2: Maximum span, 11 feet; minimum rod, 3/8 inch.
 - 3. NPS 3: Maximum span, 12 feet; minimum rod, 3/8 inch.
 - 4. NPS 4: Maximum span, 14 feet; minimum rod, 1/2 inch.
- E. Support multi floor vertical runs at least at each floor.

3.6 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.

3.7 SYSTEM CHARGING

- A. Charge system using the following procedures:
1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 12 hours, system is ready for charging.
 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 4. Charge system with a new filter-dryer core in charging line.

3.8 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

SECTION 23 25 13

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.
 - 3. Glycol Automatic feed Unit
- B. Related Requirements:
 - 1. Section 232533 "HVAC Makeup-Water Filtration Equipment" for water softeners, RO equipment, and filtration equipment.

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 Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.8 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 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aqua-Chem, Inc.
 - 2. Cascade Water Services, Inc.
 - 3. Metro Group, Inc. (The).
 - 4. Watcon, Inc.
 - 5. Water Services Inc.

2.2 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, 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

2.3 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.

2.4 AUTOMATIC CHEMICAL-FEED EQUIPMENT (NOT USED)

- A. Water Meter:
1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
 2. Body: Bronze.
 3. Minimum Working-Pressure Rating: 150 psig.
 4. Maximum Pressure Loss at Design Flow: 3 psig.
 5. Registration: Gallons or cubic feet.
 6. End Connections: Threaded.
 7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
 8. 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. Water Meter:
1. AWWA C701, turbine-type, totalization meter.
 2. Body: Bronze.
 3. Minimum Working-Pressure Rating: 100 psig.
 4. Maximum Pressure Loss at Design Flow: 3 psig.
 5. Registration: Gallons or cubic feet.
 6. End Connections: Threaded.
 7. Control: Low-voltage signal capable of transmitting 1000 feet.

8. 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. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze or Epoxy-coated cast iron.
3. Minimum Working-Pressure Rating: 150 psig.
4. Maximum Pressure Loss at Design Flow: 3 psig.
5. Registration: Gallons or cubic feet.
6. End Connections: Flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
8. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
2. Molded cover with recess for mounting pump.
3. Capacity: 50 gal.

E. Chemical Solution Injection Pumps:

1. Self-priming, positive displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
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.

F. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

G. Injection Assembly:

1. Quill: Minimum NPS 1/2 with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: Two-piece, stainless steel; selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig at 200 deg F.

2.5 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.

2.6 GLYCOL MAKE UP UNIT

- A. Factory packaged and assembled simplex or duplex pump, mixing tank, and expansion tank, with level and pump controls, starters and control wiring.
- B. Reservoir
 - 1. Industrial grade polyethylene tank
 - 2. Suited for glycol solution or potable water
 - 3. 55-gallon capacity
 - 4. 2" opening on top for ventilation/fill
 - 5. Observable fluid level with scale
 - 6. Removable Lid
 - 7. Y-strainer
- C. Pump
 - 1. 10 GPM capacity at 30 psi, 1/2 HP,
 - 2. low pressure
 - 3. 5 GPM capacity at 60 psi, 3/4 HP, high pressure
 - 4. Operates as needed to restore system pressure with the solution contained in the unit's reservoir
 - 5. Pump isolation valves, check and balance valve
 - 6. Discharge pressure gage
 - 7. Motor contactor with pressure control
 - 8. System HOA switch with green running light
 - 9. Single power connection
- D. Pressure Control
 - 1. Cut off provides protection from excess pressure
 - 2. Cut in 3-10 psi, cut out 9-30 psi for GMU30
 - 3. Cut in 10-45 psi, cut out 20-60 psi for GMU60
- E. Level Control
 - 1. Safely shuts down pump when solution level is low
 - 2. Remote alarm contact
 - 3. Red indicator light
- F. Valves
 - 1. Shut-off
 - 2. Non-slam check
 - 3. Calibrated balance valve

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 chilled water dual-temperature water and glycol cooling, and equipped with the following:
 - 1. Install bypass feeder in a bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 2. Install water meter in makeup-water supply.
 - 3. Install test-coupon assembly in bypass circuit around circulating pumps unless otherwise indicated on Drawings.
 - 4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below the feeder inlet.
 - 5. 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 230523.10 "Valves for HVAC Piping," Section 230523.12

- 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 with the assistance of a factory-authorized service representative:
 - 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. At four-week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to "Performance Requirements" Article.

F. 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

SECTION 23 29 13
VARIABLE FREQUENCY DRIVES

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Variable frequency drives.

1.2 RELATED SECTIONS

- A. Section 23 21 23 - Hydronic Pumps.
- B. Section 16195 - Electrical Identification: Engraved nameplates.

1.3 REFERENCES

- A. Division 1 - Reference Standards: Requirements for references and standards.
- B. NEMA ICS 3.1 - Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-Speed Drive Systems.
- C. NEMA ICS 7 - Industrial Control and Systems: Adjustable Speed Drives.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- E. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association).
- F. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS FOR REVIEW

- A. Division 1 - Submittals: Procedures for submittals.
- B. Product Data: Provide catalog sheets showing voltage, controller size, ratings, and size of switching and over current protective devices, short circuit ratings, dimensions, and enclosure details.
- C. Shop Drawings: Indicate front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

1.5 SUBMITTALS FOR INFORMATION

- A. Division 1 - Submittals: Submittals for information.
- B. Test Reports: Indicate field test and inspection procedures and test results.

- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
- D. Manufacturer's Field Reports: Indicate start-up inspection findings.

1.6 SUBMITTALS FOR CLOSEOUT

- A. Division 1 - Contract Closeout.
- B. Operation Data: NEMA ICS 3.1. Include instructions for starting and operating controllers and describe operating limits that may result in hazardous or unsafe conditions.
- C. Maintenance Data: NEMA ICS 3.1. Include routine preventive maintenance schedule.
- D. Furnish two of each air filters.

1.7 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Division 1 - Material and Equipment: Transport, handle, store, and protect products.
- B. Accept controllers on site in original packing. Inspect for damage.
- C. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

1.9 MAINTENANCE SERVICE

- A. Division 1 - Contract Closeout.
- B. Provide service and maintenance of controller for two years from Date of Substantial Completion.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Equipment and devices can be provided by Danfoss Graham VLT 6000 Series 414-355-8800.
- B. Manufacturer Qualifications: Company specializing in manufacturing variable frequency controllers with minimum five years documented experience, and with service facilities within 50 miles of Project location.

2.2 DESCRIPTION

- A. Enclosed variable frequency controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7.
- B. Select unspecified features and options in accordance with NEMA ICS 3.1.
- C. Furnish complete variable frequency VFDs as specified herein for the pumps designated on the drawing schedules to be variable speed. All standard and optional features shall be included within the VFD enclosure, unless otherwise specified. VFD shall be housed in a metal NEMA 1 enclosure, or other NEMA type according to the installation and operating conditions at the job site. The VFD's UL listing shall allow mounting in plenum or other air handling compartments. If a NEMA 12 enclosure is required for the plenum rating, the manufacturer must supply a NEMA 12 rated VFD. VFD's used outdoors must be in a NEMA 4x rated enclosure.
- D. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump and fan control and to eliminate the need for motor derating.
- E. With the motor's rated voltage applied to the VFD input, the VFD shall allow the motor to produce full rated power at rated amps, RMS fundamental volts, and speed without using the motor's service factor. VFDs utilizing sine weighted/coded modulation (with or without 3rd harmonic injection) must provide data verifying that the motors will not draw more than full load current during full load and full speed operation.
- F. The VFD shall include an input full-wave bridge rectifier and maintain a fundamental power factor near unity regardless of speed or load.
- G. The VFD and options shall be tested to ANSI/UL Standard 508. The complete VFD, including all specified options, shall be assembled by the manufacturer, which shall be UL-508 certified for the building and assembly of option panels. Assembly of the option panels by a third-party panel shop is not acceptable. The appropriate UL stickers shall be applied to both the VFD and option panel, in the case where these are not contained in one panel. When these VFDs are to be located in Canada,

CSA or C-UL certifications shall apply. Both VFD and option panel shall be manufactured in ISO 9001 certified facilities.

- H. The VFD shall have DC link reactors on both the positive and negative rails of the DC bus to minimize power line harmonics. VFDs without DC link reactors shall provide a minimum 3% impedance line reactor.
- I. The VFD's full load amp rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 160% of rated current for up to 0.5 second while starting.
- J. The VFD shall be able to provide full torque at any selected frequency from 28 Hz to base speed to allow driving direct drive fans without derating.
- K. An automatic energy optimization selection feature shall be provided standard in the VFD. This feature shall automatically and continually monitor the motor's speed and load and adjust the applied voltage to maximize energy savings and provide up to an additional 3% to 10% energy savings.
- L. Input and output power circuit switching shall be able to be accomplished without interlocks or damage to the VFD. Switching rate may be up to 1 time per minute on the input and unlimited on the output.
- M. An automatic motor adaptation test algorithm shall measure motor stator resistance and reactance to optimize performance and efficiency. It shall not be necessary to run the motor or de-couple the motor from the load to run the test.
- N. Galvanic and/or optical isolation shall be provided between the VFD's power circuitry and control circuitry to ensure operator safety and to protect connected electronic control equipment from damage caused by voltage spikes, current surges, and ground loop currents. VFDs not including either galvanic or optical isolation on both analog I/O and discrete I/O shall include additional isolation modules.
- O. VFD shall minimize the audible motor noise through the use of an adjustable carrier frequency. The carrier frequency shall be automatically adjusted to optimize motor and VFD efficiencies while reducing motor noise.

2.3 PROTECTIVE FEATURES

- A. A minimum of Class 20 I²t electronic motor overload protection for single motor applications and thermal-mechanical overloads for multiple motor applications shall be provided.
- B. Protection against input transients, loss of AC line phase, output short circuit, output ground fault, over voltage, under voltage, VFD over temperature and motor over temperature. The VFD shall display all faults in plain English. Codes are not acceptable.
- C. Protect VFD from sustained power or phase loss. The VFD shall provide full rated output with an input voltage as low as 90% of the nominal. The VFD will continue to

operate with reduced output with an input voltage as low as 164 V AC for 208/230-volt units, and 313 V AC for 460-volt units.

- D. The VFD shall incorporate a motor preheat circuit to keep the motor warm and prevent condensation build up in the stator.
- E. VFD package shall include semi-conductor rated input fuses to protect power components.
- F. To prevent breakdown of the motor winding insulation, the VFD shall be designed to comply with IEC Part 34-17. Otherwise, the VFD manufacturer must ensure that inverter rated motors are supplied.
- G. VFD shall include a "signal loss detection" circuit to sense the loss of an analog input signal such as 4 to 20 mA or 2 to 10 V DC and shall be programmable to react as desired in such an instance.
- H. VFD shall function normally when the keypad is removed while the VFD is running and continue to follow remote commands. No warnings or alarms shall be issued as a result of removing the keypad.
- I. VFD shall catch a rotating motor operating forward or reverse up to full speed.
- J. VFD shall be rated for 100,000 amp interrupting capacity (AIC).
- K. VFD shall include current sensors on all three output phases to detect and report phase loss to the motor. The VFD will identify which of the output phases is low or lost.
- L. VFD shall continue to operate without faulting until input voltage reaches 300 V AC on 208/230-volt VFDs, and 539 V AC on 460-volt VFDs.
- M. All three pole variable frequency controllers (VFD) either integral to equipment or field supplied shall contain voltage fault protection specifically designed to protect all motors and all other 3 phase loads, and associated control circuits from failure or damage due to voltage unbalance, over/under voltage, phase loss, reversal, incorrect sequencing and rapid short cycling." The VFD shall be arranged to monitor critical faults including phase loss or reversal, and when detected, de-energize the load. It shall monitor non-critical faults including high/low voltage, voltage unbalance and when detected, after a time delay de-energize the load."

2.4 INTERFACEFEATURES

- A. Hand/Start, Off/Stop and Auto/Start selector switches shall be provided to start and stop the VFD and determine the speed reference.
- B. The VFD shall be able to be programmed to provide a 24 V DC output signal to indicate that the VFD is in Auto/Remote mode.

- C. The VFD shall provide digital manual speed control. Potentiometers are not acceptable.
- D. Lockable, alphanumeric backlit display keypad can be remotely mounted up to 10 feet away using standard 9-pin cable.
- E. The keypads for all sizes of VFDs shall be identical and interchangeable.
- F. To set up multiple VFDs, it shall be possible to upload all setup parameters to the VFD's keypad, place that keypad on all other VFDs in turn and download the setup parameters to each VFD. To facilitate setting up VFDs of various sizes, it shall be possible to download from the keypad only size independent parameters.
- G. Display shall be programmable to display in 9 languages including English, Spanish and French.
- H. The display shall have four lines, with 20 characters on three lines and eight large characters on one line.
- I. A red FAULT light, a yellow WARNING light and a green POWER-ON light shall be provided. These indications shall be visible both on the keypad and on the VFD when the keypad is removed.
- J. A quick setup menu with factory preset typical HVAC parameters shall be provided on the VFD eliminating the need for macros.
- K. The VFD shall include a standard RS-485 communications port and capabilities to be connected at a future date to a Johnson Controls N2 Metasys or Siemens FLN system at no additional cost to the owner. The connection shall be software selectable by the user.
- L. As a minimum, the following points shall be controlled and/or accessible:
 - 1. VFD Start/Stop
 - 2. Speed reference
 - 3. Fault diagnostics
 - 4. Meter points
 - a. Motor power in HP
 - b. Motor power in kW
 - c. Motor kW-hr
 - d. Motor current
 - e. Motor voltage
 - f. Hours run
 - g. Feedback signal #1
 - h. Feedback signal #2
 - i. DC link voltage
 - j. Thermal load on motor
 - k. Thermal load on VFD
 - l. Heat sink temperature

5. Four additional Form C 230-volt programmable relays shall be available for factory or field installation within the FD.
- M. The communication protocol shall be native BACNET, LonWorks communication shall be available for factory or field installation within the VFD.
- N. Two set-point control interface (PID control) shall be standard in the unit. VFD shall be able to look at two feedback signals, compare with two set-points and make various process control decisions.
- O. An output signal as a start command to actuate external equipment before allowing the VFD to start.
- P. The following displays shall be accessible from the control panel in actual units: Reference Signal Value in actual units, Output Frequency in Hz or percent, Output Amps, Motor HP, Motor kW, kWhr, Output Voltage, DC Bus Voltage, VFD Temperature in degrees, and Motor Speed in engineering units per application (in GPM, CFM, etc.). VFD will read out the selected engineering unit either in a linear, square, or cubed relationship to output frequency as appropriate to the unit chosen.
- Q. The display shall be programmed to read in inches of water column (in-wg) for an air handler application, pressure per square inch (psi) for a pump application, and temperature (°F) for a cooling tower application.
- R. VFD shall be able to be programmed to sense the loss of load and signal a no load/broken belt warning or fault.
- S. If the temperature of the VFD's heat sink rises to 80°C, the VFD shall automatically reduce its carrier frequency to reduce the heat sink temperature. If the temperature of the heat sink continues to rise the VFD shall automatically reduce its output frequency to the motor. As the VFD's heat sink temperature returns to normal, the VFD shall automatically increase the output frequency to the motor and return the carrier frequency to its normal switching speed.
- T. The VFD shall have temperature-controlled cooling fans for quiet operation and minimized losses.
- U. The VFD shall store in memory the last 10 faults and related operational data.
- V. Eight programmable digital inputs shall be provided for interfacing with the systems control and safety interlock circuitry.
- W. Two programmable relay outputs, one Form C 240 V AC, one Form A 30 V AC, shall be provided for remote indication of VFD status.
- X. Three programmable analog inputs shall be provided and shall accept a direct-or-reverse acting signal. Analog reference inputs accepted shall include two voltage (0 to 10 V DC, 2 to 10 V DC) and one current (0 to 20 mA, 4 to 20 mA) input.
- Y. Two programmable 0 to 20 mA analog outputs shall be provided for indication of VFD status. These outputs shall be programmable for output speed, frequency,

current and power. They shall also be programmable to provide a selected 24 V DC status indication.

- Z. Under fire mode conditions, the VFD shall be able to be programmed to automatically default to a preset speed.

2.5 ADJUSTMENTS

- A. VFD shall have an adjustable carrier frequency in steps of not less than 0.1 kHz to allow tuning the VFD to the motor.
- B. Sixteen preset speeds shall be provided.
- C. Four acceleration and four deceleration ramps shall be provided. Accel and decel time shall be adjustable over the range from 0 to 3,600 seconds to base speed. The shape of these curves shall be automatically contoured to ensure no-trip acceleration and deceleration.
- D. Four current limit settings shall be provided.
- E. If the VFD trips on one of the following conditions, the VFD shall be programmable for automatic or manual reset: under voltage, over voltage, current limit and inverter overload.
- F. The number of restart attempts shall be selectable from 0 through 20 or infinitely and the time between attempts shall be adjustable from 0 through 600 seconds.
- G. An automatic "on delay" may be selected from 0 to 120 seconds.

2.6 BYPASS

- A. Provide a manual 3-contactor bypass consisting of a door interlocked main fused disconnect padlockable in the off position, a built-in motor starter and a four position DRIVE/OFF/BYPASS/TEST switch controlling three contactors. In the DRIVE position, the motor is operated at an adjustable speed from the VFD. In the OFF position, the motor and VFD are disconnected. In the BYPASS position, the motor is operated at full speed from the AC power line and power is disconnected from the VFD so that service can be performed. In the TEST position, the motor is operated at full speed from the AC line power while power is applied to the input of the VFD. This allows the VFD to be given an operational test while continuing to run the motor at full speed in bypass. In case of an external safety fault, a customer supplied normally closed dry contact shall be able to stop the motor whether in DRIVE or BYPASS mode.
- B. Service personnel shall be able to defeat the main power disconnect and open the bypass enclosure without disconnecting power. This shall be accomplished using a specially designed tool and mechanism while meeting all local and national code requirements for safety.
- C. Bypass shall only be required for applications where equipment is stand alone. Such as an air handling unit or roof top AC unit. For application where redundant pumps, fans or other equipment and the standby equipment utilizes a VFD bypass is not required.

- D. Bypass is not required on redundant equipment ie. Pumps.

2.7 SERVICE CONDITIONS

- A. Ambient temperature, -10 to 40°C (14 to 104°F).
- B. 0 to 95% relative humidity, non-condensing.
- C. Elevation to 3,300 feet without derating.
- D. AC line voltage variation, -10 to +10% of nominal with full output.
- E. No side clearance shall be required for cooling of any units. All power and control wiring shall be done from the bottom.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Verify that surface is suitable for controller installation.
- B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.
- C. Verify that field measurements are as indicated on shop drawings and as instructed by manufacturer.

3.2 INSTALLATION

- A. Section 01400 - Quality Control: Manufacturer's instructions.
- B. Install in accordance with NEMA ICS 3.1.
- C. Tighten accessible connections and mechanical fasteners after placing controller.
- D. Provide fuses in fusible switches; refer to Section 16477 for product requirements.
- E. Select and install overload heater elements in motor controllers to match installed motor characteristics.
- F. Provide engraved plastic nameplates; refer to Section 16195 for product requirements and location.
- G. Neatly type label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating. Place in clear plastic holder.

3.3 FIELD QUALITY CONTROL

- A. Inspect and test in accordance with NETA ATS, except Section 4.
- B. Perform inspections and tests listed in NETA ATS, Section 7.16.2.

3.4 MANUFACTURER'S FIELD SERVICES

- A. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

3.5 ADJUSTING

- A. Division 1 - Contract Closeout.
- B. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

3.6 DEMONSTRATION AND INSTRUCTIONS

- A. Division 1 - Contract Closeout:
- B. Demonstrate operation of controllers in automatic and manual modes. Furnish 2 (1) one hour training sessions on the project site with the owner, by factory authorized personal.

END OF SECTION

SECTION 23 31 13

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 and flat-oval ducts and fittings.
3. Double-wall round and flat-oval ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealants and gaskets.
7. Hangers and supports.
8. 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. 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.

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.
3. Product Data: For sealants, indicating VOC content.
4. Laboratory Test Reports: For sealants, indicating compliance with requirements for low-emitting materials.
5. Laboratory Test Reports: For antimicrobial coatings, 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.
13. Seismic restraints, where applicable
14. 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. For seismic bracing only

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, IT/AV devices.
 - d. Sprinklers.
 - e. Fire alarm devices.
 - f. Owner equipment.
 - g. Access panels.
 - h. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 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 D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE/IES Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

C. Construct ductwork to NFPA 90A and NFPA 90B standards. All work, materials and equipment shall comply with the latest requirements of NFPA 90A, standards and the local authorities having jurisdiction.

D. All ductwork and fan and apparatus plenums constructed and having supported in accordance with the latest standards of the ASHRAE Guide and the Sheet Metal and Air Conditioning Contractors National Association (SMACNA).

E. Bracing, gauges, and supports indicated in SMACNA manuals are the minimum acceptable. Additional bracing or supports shall be installed to eliminate any distortion or vibration when the systems are operating or under tests.

PART 2 PRODUCTS

2.1 GENERAL

- A. General: Non-combustible or conforming to requirements for Class 1 air duct materials, or UL 181.
- B. Galvanized Steel Ducts: ASTM A525 and ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz per sq ft for each side in conformance with ASTM A90.
- C. Dissimilar Metals: Separate connections between dissimilar metals with Dielectric Insulation. Joints between dissimilar metal duct sections to be made with Companion flanges separated by a Neoprene gasket.
- D. Fasteners: Rivets, bolts, screws, and other hardware used in the sheet metal construction to be constructed of materials identical or similar to the duct material to prevent galvanic corrosion.
- E. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape, or heavy mastic as manufactured by 3M Company EC-800.
- F. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

2.2 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. Provide products from one of the following manufactures:
 - 1. McGill Airflow LLC
 - 2. Zen Industries
 - 3. Lindab
 - 4. Spiral Manufacturing Co. Inc
- B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- D. 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."
- E. 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."
- F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard." For standard applications
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.
- G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B. For Humid and damp area applications including Natatoriums and Saunas.
- H. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.
- I. Formed-on Transverse Joints (Flanges): 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."
- J. 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."

2.4 SINGLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
- B. Provide products from one of the following manufactures:
 - 1. McGill Airflow LLC
 - 2. Zen Industries
 - 3. Lindab
 - 4. Spiral Manufacturing Co. Inc
- C. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
- D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
- E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
- F. 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."

2.5 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

- A. Provide products from one of the following manufactures:
 - 1. McGill Airflow LLC
 - 2. Zen Industries
 - 3. Lindab
 - 4. Spiral Manufacturing Co. Inc

- B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
 - 1. 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."
 - a. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.
 - 2. 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."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - b. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.
 - 3. 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."
- D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.
- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard." For standard applications.
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.
- A. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B. For application in damp or humid environments including natatoriums and Saunas.

2.6 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: G90.
 - 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: G90.
 - 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 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. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. 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: Black OR White.
 - 6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
- H. 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.
- I. 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.

2.7 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."
 - a. Maximum Thermal Conductivity:
 - 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.
 2. 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.
 3. Solvent Water-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
- B. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- C. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B. For application in damp or humid environments including natatoriums and Saunas.
- D. Insulation Pins and Washers:
 1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-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, aluminum, or stainless steel to match ductwork; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- E. 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.

2.8 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: 4 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.

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. Maximum Static-Pressure Class: 10-inch wg, positive or negative.
9. Service: Indoor or outdoor.
10. 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.

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.9 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.

2.10 SEISMIC-RESTRAINT DEVICES

- A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service or 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.
- B. 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.
- C. Restraint Cables: ASTM A 603, galvanized or ASTM A 492, stainless-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
- D. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod.
- 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 and with fewest possible joints
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 0 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 2 inch, plus allowance for insulation thickness and with sufficient space around equipment to allow normal operating and maintenance activities. Provide easements where ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.
- H. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.
- 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 all installations as well as 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."

- M. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- N. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound.
- O. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
- P. Where ductwork penetrates roofs or outside walls, seal the space around ductwork airtight with fire rated expanding spray foam sealer similar to 3-M Fire Block Foam. This also applies to duct roof penetrations into roof curbs.
- Q. All ductworks shall be inspected, and pressure tested prior to enclosing in general construction or concealment above hung ceilings.

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. Use clear duct sealant.
- 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.
- F. Where indicated on plans, and specifically gymnasium, stage and cafeteria, Prime ductwork, and paint with one coat enamel base paint. Color as per architectural plans. All ductwork surface finish shall be treated prior to priming by "pickling" in accordance with industry standards and paint manufactures requirements.
- G. All exposed ductwork throughout areas of the building without ceilings shall be double wall round or oval spiral ductwork. Ductwork shall be cleaned, clear of stickers, primed and painted. Submit paint color chart for review and approval. Primer shall be specifically formulated for galvanized steel.
- H. Duct sealants used on exposed ductwork of any type shall be clear.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. No 16 USSG black steel.
- B. 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.
- C. 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. Cleanout doors on horizontal duct shall be mounted on side of duct. Bottom edge shall be not less than 2 inch above bottom of duct. Cleanout doors at vertical ducts shall be mounted at base. Door and frame shall be same gauge as duct. Hinges shall be Ventlock No. 260, extra heavy zinc plated. Latches shall be Ventlock No. 140, cast zinc. Gaskets shall be between door and frame. Gaskets shall be 1/8-inch double thickness rated for 2000-degree F. Cleanout door size shall be 24 inch one side, and other side shall be 2 inch less than duct height. Where openings are too large for side installation the opening shall be installed on the top or bottom, in accordance with approved methods. Where duct dimensions preclude top or bottom installation install clean outs ON THE duct face that will allow the largest opening with edges as described above.
- D. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
- E. All seams, joints and penetrations shall be liquid tight continuous external arc welded, except where the duct stub collar of the hood is connected to the exhaust duct. Connection to the hood shall be continuous liquid tight external arc welded or in accordance with the NFPA 96.
- F. Angle reinforcing shall be minimum 1 1/2-inch X 1 1/2-inch X 3/16 inch at maximum 4 ft. on centers and in accordance with SMACNA Rectangular Industrial Duct Contraction Standards shall be mounted.
- G. Duct to hood joints shall be made with continuous liquid tight external welds. Alternatively, the joint shall be made by flange. Flanges shall be 1" wide full perimeter fully welded. Flange connections shall have gaskets rated for 1500°f, secured by .25" dia (minimum) bolts on 4" centers for the full perimeter secured with lock washers.
- H. Duct to fan connections shall be made in a similar fashion as duct to hood connections. Where vibration isolation is required, flexible duct connections to fans shall be made coated fabric flexible connectors listed & labeled for the application.
- I. Horizontal grease ducts less than 75' long shall be installed to slope toward hoods at a rate of 3" per foot. Horizontal grease ducts of 75' or longer shall slope toward hoods at a rate of 1" per foot.
- J. Commercial kitchen exhaust duct insulation: 1" fire resistant duct wrap consisting of light weight, non-asbestos high temperature non-organic ceramic fiber blanket encapsulated in foil/scrim having a service temperature rating of 2300° f. Wrap shall be applied in two layers to provide a two-hour rated enclosure assembly. Bonding

material shall be 304 stainless steel, $\frac{3}{4}$ " wide and .015" thick. Install layers as per the manufactures details and specifications to achieve the required fire rating.

3.4 DUCT SEALING

- A. Seal ducts at a minimum to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible": typical for all services.

Leakage and Seal Classification Table					
System operating pressure in wc			<2" low	2"≥med<3"	High≥3"
Seal Class			C	B	A
Sealing			Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor			24	12	4
In addition to the above, any variable air volume system duct of 1" and $\frac{1}{2}$ " wg construction class that is upstream of the VAV boxes shall meet 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 interval 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.
- G. Where hanger rods must pierce ducts, provide closure plates around rods and fasten to duct using screws, rivets or welding. Seal with sealing compound

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 SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." 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 evaluation service member of the ICC Evaluation Service or 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.
- C. Smoke purge supply and exhaust systems and stair pressure systems. Flexible connection shall be permitted at diffusers, a maximum of 3' long, and flexible connections are permitted at air handling equipment for vibration isolation only.
- D. INSULATED FLEXIBLE DUCTS
 1. UL 181, Class 0, interlocking spiral of aluminum foil; fiberglass insulation; polyethylene vapor barrier film.
 2. Pressure Rating: 8 inches WG positive or negative.
 3. Maximum Velocity: 5000 fpm
 4. Temperature Range: -20 degrees F to 250 degrees F.

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. All Ducts with a Pressure Class equal to or Higher Than 2-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each system of the designated pressure class.
 - b. All smoke purge system Ducts, including supply exhaust and return air. All stair pressurization ductwork. Test representative duct sections totaling no less than 50 percent of total installed duct area of each system.
 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 SMOKE AND HEAT DETECTOR INSTALLATION

- A. Duct mounted smoke and heat detectors will be supplied under the Electrical Division. This Contractor to coordinate duct sizes and provide labor to install sensing probes into ductwork.

3.12 DUCTWORK PROTECTION

- A. Duct work under construction or alteration shall not be left open ended during dust producing construction. All new and existing ductwork systems in alteration or under construction shall be protected during construction. Open ends ducts shall be sealed with sheet metal or as approved.
- B. For unenclosed buildings ductwork shall be kept dry and watertight. Seal open ends watertight during construction to prevent water infiltration. Keep all acoustical lining dry during construction. Lining that has become wet shall be replaced. All incomplete ductworks being used to condition spaces in phase I or phase II that will be completed under a later phase must be protect from being internally contaminated by construction dust. All returns opening must have filters placed over them to prevent dust from being returned to the unit.

3.13 DUCT SCHEDULE

A. Fabricate ducts using the following material:

1. Underground Ducts: Concrete-encased, PVC-coated, stainless steel, fiberglass
2. Natatorium ductwork – PVC coated.
3. Kitchen exhaust – welded stainless steel or black steel 18 gage.
4. Smoke purge ductwork - welded stainless steel or black steel. 18 gage.
5. Shower room exhaust – aluminum
6. Dryer exhaust – aluminum
7. Outside air intake plenum and ductwork - Aluminum
8. All exposed ductwork in any occupied area, (does not include MER), shall be constructed of double wall round or oval spiral ductwork.

B. Duct Pressure class:

1. All duct systems shall be constructed to have a pressure classification based on the maximum static pressure (positive or negative) developed by the air handling apparatus connected to the ductwork system. Unless otherwise noted below, refer to the equipment schedules and equipment notes for the design operating pressure of each system. Systems with operating pressures between pressure classes shall be constructed to the next higher-pressure class.

Pressure Classification Table						
System operating pressure (OP) in wc	OP≤1"	1"≥OP<2"	2"≥OP<3"	3"≥OP<4"	4"≥OP<6"	6"≥OP<10"
SMACNA Construction classification	1"	2"	3"	4"	6"	10"

2. All ductworks shall be constructed in accordance with the leakage and seal classification. Note that the leakage and seal classification required by current code is more stringent than SMACNA requirements.
3. The following Leakage and Seal Classification Table applies to all ductwork, supply, exhaust, or return air, rectangular, round, or oval single or double wall. Every system

Leakage and Seal Classification Table					
System operating pressure in wc			<2" low	2"≥med<3"	High≥3"
Seal Class			C	B	A
Sealing			Transverse joints	Transverse joints and seams	Transverse joints and seams and all wall penetrations
Leakage class CL factor			24	12	4
In addition to the above, any variable air volume system duct of 1" and 1/2" wg construction class that is upstream of the VAV boxes shall meet Seal Class C.					

C. 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.
4. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.

D. Liner for sound attenuation:

1. Supply, Return and exhaust air ducts: 1/2" inches thick.
2. Supply and return fan Plenums: 1" inches thick.
3. Transfer Ducts: 1 inch thick.
4. Ductwork downstream from VAV boxes for 15', 1" thick.
5. At the inlet and discharge of all fans for a distance of 20'
- 6.

E. Double-Wall Duct Interstitial Insulation:

1. Supply, Return, Exhaust Air Ducts: 1" inches thick. (when ducts are exposed in the conditions space)
2. Supply, Return, Exhaust Air Ducts: 1 1/2" inches thick. (when ducts are concealed in plenums or are in unconditioned spaces)

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

- a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
- a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with turning vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
- a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - 4) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter:

- c. Round Elbows, 14 Inches and Larger in Diameter:

G. 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 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.14 DUCTWORK PRESSURE TESTING

- A. All high-pressure ductwork design or operated at 3" wc or greater shall pressure tested in accordance with specification section 23 05 93 Testing Adjusting and Balancing.
- B. The contractor review test report results and repair or replace any sections of ductwork with and air leakage rate over 4.0.

END OF SECTION

SECTION 23 33 00

AIR DUCT ACCESSORIES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Flexible connectors.
16. Duct accessory hardware.
17. Duct Roof Supports

- B. Related Requirements:

1. Section 233113 Metal Ducts
2. Section 233346 "Flexible Ducts" for insulated and non-insulated flexible ducts.

1.3 ACTION SUBMITTALS

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

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

C. 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. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.
 - f. Wiring Diagrams: For power, signal, and control wiring.

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.
- B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

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: G90.
 - 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 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 were 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 AND PRESSURE RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. Pottorff.
 - 4. Ruskin Company.
 - 5. Buckley
- B. Description: Gravity balanced.
- C. Maximum Air Velocity: 1000 fpm.

- D. Maximum System Pressure: up to 6" wc.
- E. Frame: Hat-shaped, [0.094-inch-thick, galvanized sheet steel] [0.063-inch-thick extruded aluminum] [0.03-inch-thick stainless steel] [0.05-inch-thick stainless steel], with welded corners or mechanically attached [and mounting flange].
- F. Blades: Multiple single-piece blades, center pivoted, or off-center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum, or 0.050-inch-thick aluminum sheet noncombustible, tear-resistant, neoprene-coated fiberglass with sealed edges.
- G. Blade Action: Parallel.
- H. Blade Seals: Neoprene, mechanically locked.
- I. Blade Axles:
 - 1. Material: Galvanized, steel Stainless steel, or Aluminum.
 - 2. Diameter: 0.20-inch min.
- J. Tie Bars and Brackets: Aluminum or Galvanized steel.
- 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: Front mounted in sleeve.
 - a. Sleeve Thickness: 20 gage minimum.
 - b. Sleeve Length: 6 inches minimum.
 - 6. Screen Mounting: Rear mounted.
 - 7. Screen Material: Galvanized steel or Aluminum.
 - 8. Screen Type: Bird. ½ x ½ max opening
 - 9. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation.
 - 2. Nailor Industries Inc.
 - 3. Pottorff.
 - 4. Ruskin Company.
 - 5. Buckley

- B. Suitable for horizontal or vertical mounting.
- C. Maximum Air Velocity: 1000 fpm.
- D. Maximum System Pressure: up to 6-inch wg.
- E. Frame: Hat-shaped, [0.05-inch-thick, galvanized sheet steel] [0.094-inch-thick, galvanized sheet steel] [0.063-inch-thick extruded aluminum] [0.03-inch-thick stainless steel] [0.05-inch-thick stainless steel], with welded corners or mechanically attached [and mounting flange].
- F. Blades:
 - 1. Multiple, 0.025-inch-thick, roll-formed aluminum or 0.050-inch-thick aluminum sheet.
 - 2. Maximum Width: 6 inches.
 - 3. Action: Parallel.
 - 4. Balance: Gravity.
 - 5. Eccentrically pivoted or Off-center pivoted.
- G. Blade Seals: Neoprene.
- H. Blade Axles: Galvanized steel, aluminum, or Stainless steel.
- I. Tie Bars and Brackets:
 - 1. Material: Aluminum or Galvanized steel.
 - 2. Rattle free with 90-degree stop.
- J. Return Spring: Adjustable tension.
- K. Bearings: Synthetic, Stainless steel, Bronze.
- L. Accessories:
 - 1. Flange on intake.
 - 2. Adjustment device to permit setting for varying differential static pressures.

2.5 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flex-Tek Group.
 - b. McGill AirFlow LLC.
 - c. Nailor Industries Inc.
 - d. Pottorff.
 - e. Ruskin Company.
 - f. Vent Products Co., Inc.

- g. Buckley
 - 2. Standard leakage rating, with linkage outside airstream.
 - 3. Suitable for horizontal or vertical applications.
 - 4. Frames:
 - a. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
 - 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 or Stainless-steel, 0.064 inch thick.
 - 6. Blade Axles: Galvanized steel, Stainless or steel Nonferrous metal.
 - 7. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve.
 - 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, provide products by one of the following:
 - a. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - e. Vent Products Co., 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 or Stainless steel.
 - 7. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, or Stainless-steel sleeve.
 - 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. Low-Leakage, Steel, Manual Volume Dampers:
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - e. Vent Products Co., Inc.
 - 2. Comply with AMCA 500-D testing for damper rating.
 - 3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
 - 4. Suitable for horizontal or vertical applications.
 - 5. Frames:
 - a. U or Angle shaped.
 - b. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized or Stainless, roll-formed steel, 0.064 inch thick.
 - 7. Blade Axles: Galvanized steel or Stainless steel.
 - 8. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
 - 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.
 - 9. Blade Seals: Neoprene.
 - 10. Jamb Seals: Cambered stainless steel or aluminum.

11. Tie Bars and Brackets: Galvanized steel or Aluminum.
12. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McGill AirFlow LLC.
 - b. Nailor Industries Inc.
 - c. Pottorff.
 - d. Ruskin Company.
 - e. Vent Products Co., Inc.
2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.
5. Frames: U or Angle-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Roll-Formed Aluminum Blades: 0.10-inch-thick aluminum sheet.
 - d. Extruded-Aluminum Blades: 0.050-inch-thick extruded aluminum.
7. Blade Axles: Galvanized steel, Stainless steel.
8. Bearings:
 - a. Oil-impregnated bronze, Molded synthetic, Oil-impregnated stainless-steel sleeve, Stainless-steel sleeve.
 - 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.
9. Blade Seals: Neoprene.
10. Jamb Seals: Cambered stainless steel, aluminum.
11. Tie Bars and Brackets: Galvanized steel, Aluminum.
12. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:

1. Size: 0.5-inch diameter min.
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.

F. 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 CONTROL DAMPERS

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

1. Arrow United Industries.
2. Greenheck Fan Corporation.
3. McGill AirFlow LLC.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.

B. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. U or Angle shaped.
2. 0.094-inch-thick, galvanized sheet steel or 0.05-inch-thick stainless steel.
3. Mitered and welded corners.

D. Blades:

1. Multiple blades with maximum blade width of 6 inches.
2. Parallel blade for non-modulating application
3. Opposed-blade design for all modulating applications.
4. Galvanized-steel, Stainless steel, Aluminum.
5. 0.064-inch-thick single skin or 0.0747-inch-thick dual skin.
6. Blade Edging: Closed-cell neoprene.
7. Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.

E. Blade Axles: 1/2-inch-diameter; galvanized steel, or stainless steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Oil-impregnated bronze, Molded synthetic, Oil-impregnated, stainless-steel sleeve, or Stainless-steel sleeve.

2. 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.
3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Arrow United Industries.
 2. Greenheck Fan Corporation.
 3. Nailor Industries Inc.
 4. Pottorff.
 5. Ruskin Company.
 6. Ward Industries; a brand of Hart & Cooley, Inc.
- B. Type: Dynamic; rated and labeled according to UL 555 by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 and 3 hours.
- E. Frame: Curtain type with blades inside airstream for application in duct over 24" in height. Curtain type with blades outside airstream for ducts 24" or less in height. Multiple-blade type; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 1. Minimum Thickness: 0.138-inch up to 4 SF 0.39 over 4 SF inch thick, as indicated, and of length to suit application.
 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated.
- H. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

2.8 CEILING RADIATION DAMPERS

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

1. Aire Technologies.
2. Nailor Industries Inc.
3. Pottorff.
4. Prefco.
5. Ruskin Company.

B. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links.

F. Fire Rating: 1hr for applications in assemblies up to 1 ½hr rating. 2hr for application in assemblies of up to 3hr

2.9 SMOKE DAMPERS

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

1. Greenheck Fan Corporation.
2. Nailor Industries Inc.
3. Pottorff.
4. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection. Except for NYC smoke detector shall be provided by the fire alarm contractor.

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded or mechanically attached corners and mounting flange.

E. Blades: Roll-formed, horizontal, overlapping, 0.063-inch- thick, galvanized sheet steel.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.05-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking.

I. Damper Motors: Modulating or two-position action.

- J. Comply with NEMA designation, temperature rating, service factor, enclosure type, 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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 7. Electrical Connection: [115 V, single phase, 60 Hz].

K. Accessories:

1. Auxiliary switches for signaling fan control and position indication.
2. Test and reset switches, damper or remote mounted.
3. Manual damper testing by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.
4. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
5. Dual Position Indicator Switch Package: Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.
6. Duct Smoke Detector: Factory mounted in the damper sleeve with interconnecting wiring from the damper actuator to the smoke detector enabling a single power connection point for easy field wiring.

2.10 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
 2. Pottorff.
 3. Ruskin Company.

- B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.
- C. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.
- D. Fire Rating: 1-1/2 for assemblies up to 2 hour and 3hr rating for assemblies over 1 1/2hours.
- E. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.
- F. Primary heat responsive device set at 285 deg F, resettable.
- G. Secondary heat closure device, set at 350 deg F, resettable.
- H. Smoke Detector: Integral, factory wired for single-point connection.
- I. Blades: Roll-formed, horizontal, interlocking, 0.063-inch- thick, galvanized sheet steel.
- J. Leakage: Class I.
- K. Rated pressure and velocity to exceed design airflow conditions.
- L. Mounting Sleeve: Factory-installed, 0.039-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.
- M. Master control panel for use in dynamic smoke-management systems.
- N. Damper Motors: Modulating or two-position action.
- O. Comply with NEMA designation, temperature rating, service factor, enclosure type, 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. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.

P. Accessories:

A. DRS-30 Two-Temperature Fire Closure Device:

1. UL classified two-temperature device permits the damper to be re-opened after initial temperature closure allowing the damper to remain operable for smoke management purposes until the high temperature limit is reached.
2. Manual damper testing is permitted by physically depressing the low temperature thermal disc from the inside of the damper sleeve and resetting the sensor from the exterior side of the damper sleeve.
3. Dual position blade indicator switch package shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.

B. PI-50 Dual Position Indicator Switch Package: Shall connect directly to the blade axel for positive annunciation (interconnecting arms, wire-forms, or brackets shall not be accepted) and provide full open and full closed blade indication to a remote location.

C. Duct Smoke Detector: Factory mounted in the damper sleeve with interconnecting wiring from the damper actuator to the smoke detector enabling a single power connection point for easy field wiring.

2.11 FLANGE CONNECTORS

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

1. CL WARD & Family Inc.
2. Ductmate Industries, Inc.
3. Hardcast, Inc.
4. 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.

2.12 DUCT SILENCERS

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

1. Industrial Noise Control, Inc.
2. McGill AirFlow LLC.
3. Ruskin Company.
4. Vibro-Acoustics.

5. Industrial Acoustics

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. Rectangular straight with splitters or baffles.
2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90 , galvanized sheet steel, 0.040 inch thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.05 inch thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, G60 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss to achieve STC 45.

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. Dissipative or Film-lined type with fill material.
 - a. Fill Material: Inert and vermin-proof fibrous material, packed under not less than 15 percent compression and Moisture-proof nonfibrous material.
 - b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: Fiberglas cloth.
- J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
1. Joints: Lock formed and sealed or continuously welded or flanged connections.
 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 3. Reinforcement: Cross or trapeze angles for rigid suspension.
- K. Accessories:
1. Integral 1-1/2 3-hour fire damper with access door. Access door to be high transmission loss to match silencer.
 2. Factory-installed end caps to prevent contamination during shipping.
 3. Removable splitters.
 4. Airflow measuring devices.
- L. Source Quality Control: Test according to ASTM E 477.
1. Testing to be witnessed by Engineer.
 2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.
 3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.
- M. Capacities and Characteristics:
1. Configuration: Straight or 90-degree elbow as indicated on plan
 2. Shape: Rectangular or Round as indicated on plan
 3. Attenuation Mechanism: Acoustical glass fiber with protective film liner.
 4. Maximum Pressure Drop: 0.25-inch wg.
 5. Casing:
 - a. Attenuation: Standard.
 - b. Outer Material: Galvanized steel.
 - c. Inner Material: Galvanized steel.
 6. Velocity Range: 500 fpm max.
 7. End Connection: 1-inch slip joint or Flange.
 8. Length: as per plan
 9. Face Dimension:
 - a. Width: as per plan
 - b. Height: as per plan
 10. Face Velocity: as per plan
 11. Dynamic Insertion Loss: as per plan
 12. Generated Noise: as per plan
 13. Accessories:

- a. Access door.
- b. Birdscreen.

2.13 TURNING VANES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Aero-Dyne Sound Control Co.
 - 2. CL WARD & Family Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Duro Dyne Inc.
 - 5. METALAIRE, Inc.
 - 6. 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. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- E. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.14 REMOTE DAMPER OPERATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pottorff.
 - 2. Ventfabrics, Inc.
 - 3. Young Regulator Company.
- B. Description: Cable system designed for remote manual damper adjustment.
- C. Tubing: Copper or Aluminum.
- D. Cable: Steel.
- E. Wall-Box Mounting: Recessed.

- F. Wall-Box Cover-Plate Material: Stainless steel.

2.15 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. CL WARD & Family Inc.
 2. Ductmate Industries, Inc.
 3. Greenheck Fan Corporation.
 4. McGill AirFlow LLC.
 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-inchbutt 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 for plenum applications.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges or Continuous and two compression latches with outside and inside handles.
- C. Pressure Relief Access Door:
1. Door and Frame Material: Galvanized sheet steel.
 2. Door: Double wall with insulation fill 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 at 3.0- to 8.0-inch wg.
 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.

2.16 DUCT ACCESS PANEL ASSEMBLIES

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

2.17 FLEXIBLE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. CL WARD & Family Inc.
 - 2. Ductmate Industries, Inc.
 - 3. Duro Dyne Inc.
 - 4. Elgen Manufacturing.
- 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 or 5-3/4 inches wide attached to two strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- 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. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
 - 1. Minimum Weight: 16 oz./sq. yd.
 - 2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F.
- H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: 14 oz./sq. yd.
 - 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67 to plus 500 deg F.
- I. 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.

2.18 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.19 DUCT ROOF SUPPORTS

- A. Ductwork shall be supported a minimum of 12" above the roof with "H" stand manufactured by RTS. Roof support systems. All parts shall be manufactured from hot dipped galvanized steel 1 5/8" channels. All fasteners shall be hot dipped galvanized steel or nickel plated. All channels that are filed cut shall be finished with cold galvanizing at all unfinished edges. All stands shall have two lateral horizontal cross members.

- B. "H" stands shall use double base. Gusseted 2"x2" square receiver base plate mounted on 14.5"x17.5" x2" thick neoprene pad model RTSF21G.

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. Compliance with ASHRAE/IESNA 90.1-2004 includes Section 6.4.3.3.3 - "Shutoff Damper Controls," restricts the use of backdraft dampers, and requires control dampers for certain applications. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
 - 3. Install stainless steel volume dampers in stainless steel ducts.
- E. Set dampers to fully open position before testing, adjusting, and balancing.
- F. Install test holes at fan inlets and outlets and elsewhere as indicated.
- G. Install fire and smoke dampers according to UL listing.
- H. Connect ducts to duct silencers rigidly.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans and seals.
 - 5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for

- access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-foot spacing and the bottom of all riser in Laundry exhaust ducts.
 - 8. Upstream from turning vanes.
 - 9. Upstream or downstream from duct silencers.
 - 10. Control devices requiring inspection.
 - 11. Elsewhere as indicated.
 - J. Install access doors with swing against duct static pressure.
 - K. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 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.
 - L. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
 - M. Install flexible connectors to connect ducts to equipment.
 - N. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
 - O. Connect terminal units to supply ducts with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
 - P. Connect diffusers or light troffer boots to ducts with maximum 30-inch lengths of flexible duct clamped or strapped in place.
 - Q. Connect flexible ducts to metal ducts with draw bands.
 - R. Install duct test holes where required for testing and balancing purposes.
 - S. 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.
 - T. Install remote volume damper operators for all volume dampers that are concealed and not accessible after finished construction is complete.
- 3.2 FIELD QUALITY CONTROL
- A. Tests and Inspections:
 - 1. Operate dampers to verify full range of movement.

2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION

SECTION 23 34 23

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. Utility set fans.
 - 2. Centrifugal roof ventilators.
 - 3. Axial roof ventilators.
 - 4. Centrifugal wall ventilators.
 - 5. In-line centrifugal fans.
 - 6. Propeller fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
- 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.
 - 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. 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.
 2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
 - D. Coordination Drawings: 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. Roof framing and support members relative to duct penetrations.
 2. Ceiling suspension assembly members.
 3. Size and location of initial access modules for acoustical tile.
 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
 - E. Field quality-control reports.
 - F. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.
- 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. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
 - C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.
- 1.6 COORDINATION
- A. Coordinate size and location of structural-steel support members.
 - B. Coordinate sizes and locations of concrete bases with actual equipment provided.
 - C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.
- 1.7 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. Belts: 2 set(s) for each belt-driven unit.

PART 2 PRODUCTS

2.1 UTILITY SET FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ACME Company.
 2. Loren Cook Company.
 3. New York Blower Company
 4. PennBarry.
 5. Greenheck.
- 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; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
 1. Blade Materials: Steel or Aluminum.
 2. Blade Type: Backward inclined or Forward curved, or Airfoil. As scheduled.
 3. Spark-Resistant Construction: AMCA 99, Type [A] [B] [C]
- 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: [1.5] [1.4] [1.3] [1.2]
 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. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
11. Disconnect switch - Nonfusible type, with thermal-overload protection. Externally mounted outdoor disconnects shall be NEMA 3R.

2.2 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. ACME Company.
 2. Central Blower Company.
 3. Greenheck Fan Corporation.
 4. Loren Cook Company.
 5. PennBarry.
- 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 and grease collector (for kitchen hood applications).
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- 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.
 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:
 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit.
 3. Bird Screens: Removable, 1/2-inch mesh, aluminum, or brass wire.
 4. Barometric 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.
- F. Special Considerations for Kitchen Hood Exhaust Applications:

- a. No back-draft discharge damper for kitchen hood exhaust applications
 - b. Minimum curb Height: 12". Coordinate the exact curb height in the field so that the top of the fan is a minimum of 40" above the roof.
 - c. Roof curb shall be vented without insulation.
 - d. Provide grease drain line and cup.
 - e. Provide hinged fan.
 - f. NEMA 3R external unit mounted disconnect switch.
 - g. Bird screen with heat baffle
 - h. Fan shall be hinge mounted to curb for access to the wheel and ductwork.
 - i. UL 762 rated for continuous operation up to 300 deg F.
- G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to suit roof opening and fan base.
1. Configuration: Self-flashing without a cant strip, with mounting flange.
 2. Minimum Height: 18 inches. For Kitchen exhaust applications coordinate the curb height in the field so that the top of the fan is a minimum of 40" above the roof.
 3. Sound Curb: Curb with sound-absorbing insulation.
 4. Pitch Mounting: Manufacture curb for roof slope.
 5. Metal Liner: Galvanized steel.
 6. Burglar Bars: 1/2-inch- thick steel bars welded in place to form 6-inch squares. (Not required unless scheduled)
 7. Mounting Pedestal: Galvanized steel with removable access panel.
 8. Vented Curb: Unlined with louvered vents in vertical sides. (for kitchen hood exhaust applications)

2.3 CENTRIFUGAL WALL VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. ACME Fan Incorporated.
 4. Loren Cook Company.
 5. PennBarry.
- B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.
- C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.
- 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.
 4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 5. Fan and motor isolated from exhaust airstream.
- E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch mesh, aluminum, or brass wire.
4. Wall Grille: Ring type for flush mounting.
5. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.4 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Carnes Company.
 2. Greenheck Fan Corporation.
 3. ACME Fan Incorporated.
 4. Loren Cook Company.
 5. PennBarry.
- B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- C. Direct-Drive Units: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing.
- D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- F. Accessories:
 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent. (where scheduled or indicated on plan)
 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 3. Companion Flanges: For inlet and outlet duct connections.
 4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 6. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside or outside fan housing, factory wired through an internal aluminum conduit

2.5 PROPELLER FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Carnes Company.
 2. Chicago Blower Corporation.

3. Loren Cook Company.
 4. ACME
 5. PennBarry.
- B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
- C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
- D. Fan Wheel: Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- E. Fan Drive: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing.
- F. Fan Drive:
1. Resiliently mounted to housing.
 2. Statically and dynamically balanced.
 3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 4. Extend grease fitting to accessible location outside of unit.
 5. Service Factor Based on Fan Motor Size: 1.4.
 6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.
 8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
 9. Motor Pulleys: Adjustable pitch for use with motors through 3 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
 10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
 11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- G. Accessories:
1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
 2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
 3. Wall Sleeve: Galvanized steel to match fan and accessory size.
 4. Weathershield Hood: Galvanized steel to match fan and accessory size.
 5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
 6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 8. alkali, and solvents. Coating system shall exceed 4000-hour ASTM B117 Salt Spray Resistance.
 9. Note that 10-20 mil thick wet coating systems pollute the environment (air and water), and that these manually applied coatings are not uniform over the impeller surface and can cause fan imbalance and vibration.

- H. If Project has more than one type or configuration of propeller fan, delete paragraph below and schedule fans on Drawings.

2.6 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 15 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
- B. Enclosure Type: Totally enclosed, fan cooled.

2.7 SOURCE QUALITY CONTROL

- A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support units using spring isolators or restrained spring isolators for projects with seismic requirements having a static deflection of 1 inch. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
 - 1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- C. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- E. Support suspended units from structure using threaded steel rods and elastomeric hangers or spring hangers with vertical limit stops having a static deflection of 1 inch. Install units with clearances for service and maintenance.

- F. Label units according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section "Air Duct Accessories."
- B. Kitchen exhaust hood fans shall not have flexible connections or back draft dampers.
- C. Install ducts adjacent to power ventilators to allow service and maintenance.
- D. Prove flexible duct connections for all fans except Kitchen exhaust fans.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 9. Disable automatic temperature-control operators, energize motor, and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 10. Shut unit down and reconnect automatic temperature-control operators.
 - 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Lubricate bearings.
- D. Comply with requirements in "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- E. Mechanical schedules and equipment notes indicates estimated static pressures and resultant RPM. If, during balancing, it is determined that the sheaves supplied with and fan or air handling unit have reached the maximum adjustment and design static pressure and or CFM can not be obtained then it shall be the mechanical contractor's responsibility to remove and change the drive as required to reach design conditions. And it shall be the balancers responsibility to rebalance the system as appropriate to achieve design conditions after the drives have been changed.

END OF SECTION

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Rectangular and square ceiling diffusers.
- 2. Modular core supply grilles.

- B. Related Sections:

- 1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
- 2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated, include the following:

- 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static pressure drop, and noise ratings.
- 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

- B. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
- 2. Method of attaching hangers to building structure.
- 3. Size and location of initial access modules for acoustical tile.
- 4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- 5. Duct access panels.

- C. Source quality-control reports.

PART 2 PRODUCTS

2.1 CEILING DIFFUSERS

- A. Rectangular and Square Ceiling Diffusers:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. METALAIRE, Inc.
 - b. Nailor Industries Inc.
 - c. Price Industries.
 - d. Tuttle & Bailey.
 - 2. Devices shall be specifically designed for variable-air-volume flows.
 - 3. Material: As indicated on drawings.
 - 4. Finish: Baked enamel, color selected by Architect.

2.2 REGISTERS AND GRILLES

- A. Adjustable Bar Register:
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - a. METALAIRE, Inc.
 - b. Nailor Industries Inc.
 - c. Price Industries.
 - d. Tuttle & Bailey.
 - 2. Material: As indicated on drawings.
 - 3. Finish: Baked enamel, color selected by Architect.

2.3 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 23 41 00

PARTICULATE AIR FILTRATION

PART 1 GENERAL

1.1 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 panel filters.
 - 2. Flat panel filters.
 - 3. Pleated panel filters.
 - 4. Ring panel filters.
 - 5. Non-supported bag filters.
 - 6. Supported bag filters.
 - 7. Rigid cell box filters.
 - 8. V-bank cell filters.
 - 9. Self-supported pocket filters.
 - 10. Front- and rear-access filter frames.
 - 11. Side-service housings.
 - 12. Filter gages.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
- B. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
 - 2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
 - 3. Include diagram 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 each type of filter and rack 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. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

PART 2 PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance:
 - 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 - 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- B. Comply with NFPA 90A and NFPA 90B.
- 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.

2.2 METAL PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.

- c. Camfil Farr.
 - d. Flanders Corporation.
 - e. Purafil, Inc.
- B. Media: Four or Six alternate layers of aluminum or stainless-steel flat and herringbone-crimp screen.
 - 1. Nonoiled for grease removal application.
 - 2. Adhesive coating.
 - a. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 - b. Adhesive: As recommended by air-filter manufacturer and that complies 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. Filter-Media Frame: Aluminum Stainless steel, hinged, and with pull and retaining handles fastened to the media.
 - 1. Drain holes.
- D. Capacities and Characteristics: As per plan and schedule

2.3 FLAT PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, flat, non-pleated, panel-type, disposable air filters with holding frames.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. 3M.
 - b. AAF International.
 - c. Airguard.
 - d. Camfil Farr.
 - e. Flanders Corporation.
 - f. Purafil, Inc.
- B. Filter Unit Class: UL 900, Class 1.
- C. Media: Interlaced glass or synthetic fibers or Cotton and synthetic fibers coated with nonflammable adhesive.
 - 1. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 - 2. Adhesive: As recommended by air-filter manufacturer and that complies 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."

3. Media shall be coated with an antimicrobial agent.
 4. Metal Retainer: Upstream side and downstream side.
- D. Filter-Media Frame: Cardboard with perforated metal retainer sealed or bonded to the media.
- E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Capacities and Characteristics:
1. Face Area: as per equipment schedule.
 2. Face Dimensions: as per equipment schedule.
 3. Depth: 2".
 4. System Airflow: as per equipment schedule.
 5. Maximum or Rated Face Velocity: 350 fpm.
 6. Arrestance: 85 percent when tested according to ASHRAE 52.2.
 7. MERV Rating: 13 when tested according to ASHRAE 52.2.

2.4 PLEATED PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Flanders Corporation.
 - e. Purafil, Inc.
- B. Filter Unit Class: UL 900, Class 1.
- C. Media: Interlaced glass or synthetic fibers or Cotton and synthetic fibers coated with nonflammable adhesive.
1. Adhesive: As recommended by air-filter manufacturer and with a VOC content of 80 g/L or less.
 2. Adhesive: As recommended by air-filter manufacturer and that complies 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."
 3. Media shall be coated with an antimicrobial agent.

4. Separators shall be bonded to the media to maintain pleat configuration.
 5. Welded-wire grid shall be on downstream side to maintain pleat.
 6. Media shall be bonded to frame to prevent air bypass.
 7. Support members on upstream and downstream sides to maintain pleat spacing.
- D. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.
- E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Capacities and Characteristics:
1. Face Area: as per equipment schedule.
 2. Face Dimensions: as per equipment schedules.
 3. Thickness or Depth: 1 inch 2 inches.
 4. Surface Area: as per equipment schedule.
 5. Holding Frame Size: as per equipment schedule.
 6. Number of Filters: as per equipment scheduler.
 7. System Airflow: as per equipment schedule.
 8. Maximum or Rated Face Velocity: 550 fpm.
 9. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
 10. Arrestance: 85 percent when tested according to ASHRAE 52.2.
 11. Initial Resistance: 0.25-inch wg at 300 fpm.
 12. Recommended Final Resistance: .5 wg.
 13. MERV Rating: 11 when tested according to ASHRAE 52.2.

2.5 NONSUPPORTED BAG FILTERS

- A. Description: Factory-fabricated, dry, extended-surface, unsupported filters with header frames.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Flanders Corporation.
 - e. Purafil, Inc.
- B. Filter Unit Class: UL 900, Class 1.
- C. Media: Glass-fiber or Synthetic material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports.
1. Media shall be coated with an antimicrobial agent.
- D. Filter-Media Frame: Galvanized steel or Hard polyurethane foam.
- E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for

bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. Face Area: as per equipment schedule.
2. Face Dimensions: as per equipment schedule.
3. Thickness or Depth: as per equipment schedules.
4. Surface Area: as per equipment schedule.
5. Holding Frame Size: as per equipment schedules.
6. Number of Filters: as per equipment scheduler.
7. System Airflow: as per equipment schedule.
8. Maximum or Rated Face Velocity: 300 fpm.
9. Efficiency: 90 percent on particles 20 micrometers and larger at 500 fpm.
10. Initial Resistance: .25 wg.
11. Recommended Final Resistance: .55s wg.
12. MERV Rating: 15 when tested according to ASHRAE 52.2.

2.6 SUPPORTED BAG FILTERS

A. Description: Factory-fabricated, dry, extended-surface, self-supported filters with holding frames in steel, basket-type retainers.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Flanders

B. Filter Unit Class: UL 900, Class 1

C. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated- airflow conditions by flexible internal supports.

1. Media shall be coated with an antimicrobial agent.

D. Filter-Media Frame: Galvanized steel or Hard polyurethane foam.

E. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

F. Capacities and Characteristics:

1. Face Area: as per equipment schedule.
2. Face Dimensions: as per equipment schedules.
3. Thickness or Depth: as per equipment schedule.
4. Surface Area: as per equipment schedule.
5. System Airflow: as per equipment schedule.
6. Maximum or Rated Face Velocity: 300 fpm.

7. Arrestance: 85 percent when tested according to ASHRAE 52.2.
8. Initial Resistance: .25 wg.
9. Recommended Final Resistance: .5wg.

10. MERV Rating: 13 when tested according to ASHRAE 52.2.

2.7 FRONT- AND REAR-ACCESS FILTER FRAMES

- A. Framing System: Galvanized-steel or Aluminum framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and pre-punched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Flanders Corporation.
 - e. Purafil, Inc.
- B. Prefilters: Incorporate a separate track with spring clips, removable from front or back.
- C. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.

2.8 SIDE-SERVICE HOUSINGS

- A. Description: Factory-assembled, side-service housings, constructed of galvanized steel or aluminum, with flanges to connect to duct or casing system.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. AAF International.
 - b. Airguard.
 - c. Camfil Farr.
 - d. Flanders Corporation.
 - e. Purafil, Inc.
- B. Prefilters: Integral tracks to accommodate 2-inch-deep, disposable, or washable filters.
- C. Access Doors: Hinged, with continuous gaskets on perimeter and positive-locking devices and arranged so filter cartridges can be loaded from either access door.
- D. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

2.9 FILTER GAGES

- A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
 - 11. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 12.
 - a. AirGuard; Clarcor Air Filtration Products, Inc.
 - b. Dwyer Instruments, Inc.
 - 2. Diameter: 4-1/2 inches.
 - 3. Scale Range for Filter Media -Inch wg or Less: 0- to 3.0-inch wg.
- B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg, and accurate within 3 percent of the full-scale range.
- C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 EXECUTION

3.1 INSTALLATION

- A. Equipment Mounting:
 - 1. Install filter assemblies on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases and foundations specified in Section 033053 "Miscellaneous 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."
- B. Provide filter / filter bank for each unitary piece of equipment (i.e.: Air handlers, rooftop units, fan coil units, unit ventilators, etc.).
- C. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- D. Install filters in position to prevent passage of unfiltered air.

- E. Install filter gage for each filter bank.
- F. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- G. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
- H. Coordinate filter installations with duct and air-handling-unit installations.

3.2 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. Operate automatic roll filters to demonstrate compliance with requirements.
 - 2. Test for leakage of unfiltered air while system is operating.
- D. Air filter will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

3.3 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air- distribution systems, clean filter housings and install new filter media.

END OF SECTION

SECTION 23 73 13.13

INDOOR, BASIC AIR-HANDLING UNITS

1.1 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: Factory-assembled, indoor air-handling units with limited features.

1.3 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit.
 - 1. Unit dimensions and weight.
 - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.
 - 3. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated.
 - b. Certified fan-sound power ratings.
 - c. Fan construction and accessories.
 - d. Motor ratings, electrical characteristics, and motor accessories.
 - 4. Certified coil-performance ratings with system operating conditions indicated.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Filters with performance characteristics.
- B. Delegated-Design Submittal: For vibration isolation 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 for designing vibration isolation bases.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor 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. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.

2. Support location, type, and weight.
3. Field measurements.

- B. Source quality-control reports:
- C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling 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.
 3. Fan Belts: One set(s) for each air-handling unit fan.

1.7 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE Compliance: 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. Structural Performance: Casing panels shall be self-supporting and capable of withstanding positive/negative 4-inch wg of internal static pressure, without exceeding a midpoint deflection of 0.005 inches/inch of panel span.

2.2 INDOOR, BASIC AIR-HANDLING UNIT MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Task Applied
 - 2. Carrier Corporation; a unit of United Technologies Corp.
 - 3. Daikin Applied.
 - 4. Dunham-Bush, Inc.
 - 5. YORK; a Johnson Controls company.

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. Joints: Sheet metal screws or pop rivets.
 - 3. Sealing: Seal all joints with water-resistant sealant. Hermetically seal at each corner and around entire perimeter.
 - 4. Base Rail:
 - a. Material: Galvanized steel.
 - b. Height: 4 inches.
- B. Unit Panels:
 - 1. Casing Wall: Galvanized steel, minimum 20 gauge thick, with manufacturer's standard finish.
 - 2. Floor Plate: galvanized steel, minimum 18 gauge thick.
 - 3. Casing Insulation:
 - a. Materials: 1-in. minimum thickness dual-density fiberglass insulation with a nominal density of not less than 1.5 lb. per cubic foot.
 - b. Casing Panel R-Value: Minimum 8
 - 4. Base Rail:
 - a. Material: Galvanized steel.
 - b. Height: 4 inches min
- C. Pressure Classifications:
 - 1. For Unit Sections Upstream of Fans: Minus 2-inch wg minimum but not less than the system operating pressure.

2. For Unit Sections Downstream and Including Fans: 2-inch wg minimum, but not less than the system operating pressure.

D. Access Doors:

1. Doors:
 - a. Fabrication: Formed and reinforced with same materials and insulation thickness as casing.
 - b. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - c. Gasket: Neoprene, applied around entire perimeters of frame.
 - d. Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
2. Locations and Applications:
 - a. Provide access doors for the following sections.
 - 1) Fan Section:
 - 2) Access Section:
 - 3) Access Sections Immediately Upstream and Downstream of Coil Sections: Doors.
 - 4) Damper Section: Doors.
 - 5) Filter Section: Doors large enough to allow periodic removal and installation of filters.
 - 6) Mixing Section: Doors.

E. Condensate Drain Pans:

1. Construction:
 - a. Double wall, stainless steel; Minimum of 2" high.
2. Drain Connection:
 - a. Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
 - b. Minimum Connection Size: NPS 1 ¼".
3. 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.
4. Length: Extend drain pan downstream from leaving face for distance to comply with ASHRAE 62.1. or a minimum of 6"
5. Width: Entire width of water producing device.

2.4 FAN, DRIVE, AND MOTOR SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 - 1. Shafts: With field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - 1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 - 2. Horizontal-Flanged, Split Housing: Bolted construction.
 - 3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
 - 4. Flexible Connector: Factory fabricated with a fabric strip minimum 3-1/2 inches wide, attached to two strips of minimum 2-3/4-inchwide 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.
 - 1) Fabric Minimum Weight: 26 oz./sq. yd..
 - 2) Fabric Minimum Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3) Fabric Minimum Service Temperature Range: Minus 40 to plus 200 deg F.
- C. Forward-Curved, 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 aluminum hub swaged to backplate and fastened to shaft with setscrews. Wheels shall be bonderized steel with baked enamel, or galvanized steel.
- D. Fan Shaft Bearings:
 - 1. Self-aligning, pillow-block type with an L-50 rated life of minimum 200,000 hours according to ABMA 9.
 - 2. 4. Fan shafts shall be solid steel, turned, ground and polished
- E. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
 - 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.

2. Motor Pulleys: Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions. Motors over 5 hp shall use VFD
 3. Belts: Oil resistant, non-sparking, and non-static; in matched sets for multiple-belt drives.
 4. Belt Guards: For air-handling units with motors mounted on outside of casing. 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.
 5. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.
- F. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
1. Enclosure Type: Totally enclosed, fan cooled.
 2. NEMA Premium Efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 5. Mount unit-mounted disconnect switches on exterior of unit.
 6. Design B with sizes and electrical characteristics as shown on the equipment schedule.
 7. Service factor 1.5

2.5 COIL SECTION

- A. General Requirements for Coil Section:
1. Comply with AHRI 410.
 2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 3. Coils shall not act as structural component of unit.
 4. All coils shall have mill galvanized casings. Coils shall be factory leak tested at 450 psig air pressure.

2.6 HYDRONIC COILS (Heating or Cooling)

- A. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.
- B. Minimum Working-Pressure/Temperature Ratings:
- a. Hot water; 175 psig, 400 deg F.
 - b. Chilled water; 300 psig, 200 deg F.
- C. Source Quality Control: Factory tested to 300 psig.
- D. Tubes: ASTM B 743 copper, minimum thickness.

1. ½" OD tubes - .025" thick
 2. 5/8" OD tubes - .035" thick
 3. 7/8" OD tubes - .049" thick
- E. Fins: Aluminum, minimum thickness.
1. Plate fins – 0.0065" thick
 2. Spiral fins – 0.010" thick
- F. Headers: Seamless copper tube with brazed joints, prime coated.
- G. Frames: Galvanized-steel channel frame, minimum thickness.
1. ½" OD and smaller, up to 4 rows and not longer than 48" finned length – 18 gage galvanized steel.
 2. 5/8" OD and larger, longer than 48" and less than 72" finned length – 16 gage galvanized steel.
 3. 5/8" OD and larger, longer than 72" finned length – 14 gage galvanized steel
- H. Mounting; Slip in frame for retrofits, Flange frame for new construction.
- I. Connections:
1. Coordinate left hand, right hand connections or supply return on opposite sides in the field. Coordinate with field requirements. Use supply and return connections on the same side whenever possible.

2.7 AIR FILTRATION SECTION

- A. Particulate air filtration is specified in Section 234100 "Particulate Air Filtration."
- B. The filter section shall be designed and constructed to house the specific type of filter specified on the equipment schedule.
- C. Flat filter sections shall accept filters of standard sizes. Sections shall include side access slide rails and hinged door access. Flat filter section shall be arranged with minimum depth in direction of airflow.
- D. Angle filter section shall accept 2-in. filters arranged in horizontal V formation. Double-walled hinged doors shall be provided.
- E. Side-Access Filter Mounting Frames:
1. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized steel track.
 - a. Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

2.8 DAMPERS

- A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg.
- B. Damper Operators: Comply with requirements in Section 230923.12 "Control Dampers."
- C. Dampers shall be sectionalized to limit blade width to no more than 50-in. to minimize blade warpage and to ensure tight closure.
- D. Damper operators may be supplied by the AHU manufacturer or field supplied.
 - 1. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 - 2. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
 - 3. Operator Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - b. Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 - c. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 - 4. Non spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running torque of 150 in. x lbf and breakaway torque of 300 in. x lbf.
 - 5. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft.: Size for running and breakaway torque of 150 in. x lbf.
 - 6. Size dampers for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. of damper.
 - e. Dampers with 2- to 3-Inch wg of Pressure Drop or Face Velocities of 1000 to 2500 fpm: Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg of Pressure Drop or Face Velocities of 2500 to 3000 fpm: Increase running torque by 2.0.
 - 7. Coupling: V-bolt and V-shaped, toothed cradle.
 - 8. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - 9. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on non-spring-return actuators.
 - 10. Power Requirements (Two-Position Spring Return): 24 V dc.

11. Power Requirements (Modulating): Maximum 10 VA at 24 V ac or 8 W at 24 V dc.
 12. Proportional Signal: 2 to 10 V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 13. Temperature Rating: Minus 22 to plus 122 deg F.
 14. Run Time: 12 seconds open, 5 seconds closed.
- E. 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 zinc-plated 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.
- F. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
- G. Combination Filter and Mixing Section:
1. Cabinet support members shall hold 2-inch- thick, pleated, flat, permanent or throwaway filters.
 2. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.
 3. Mixing boxes and filter mixing boxes shall have parallel blade, interconnecting outside-air and return-air dampers.
- 2.9 Access Sections:
- A. Access sections shall be installed where indicated on the drawings and shall be as specified on the equipment schedule.
 - B. Access sections shall have double-walled hinged doors.
- 2.10 STARTERS AND DISCONNECTS
- A. All fan and damper motors shall be furnished with starter and disconnect switches.
 - B. Starters that are unit mounted may be combination motor starter/disconnect switches. When fan starters are remoted mounted, or installed in a motor control center, provide separate disconnect for all fan motors mounted on the fan section of the air handler. Refer to plans and schedules for starter / disconnect locations.
 - C. For a complete description of requirements for motor starters and combination starters/disconnects refer to specification section 23 05 13 Common motor requirements for HVAC.
 - D. Minimum requirements for starters without disconnect switch.
 1. Adjustable motor overload with trip indication.
 2. Manual overload reset button (accessible without opening enclosure).

3. 115-v fused secondary control transformer (fuse included — fused primary and secondary over 50 amps).
 4. Hand/Off/Auto selector switch (accessible without opening enclosure).
 5. Separate 4-position terminal strip for remote H-O-A wiring.
 6. C series contactors.
 7. Horsepower rated for motor applications.
 8. NEMA 4X type non-metallic enclosures.
 9. Lug connections for field wiring.
 10. Factory mounted, wired, and run tested with factory-supplied motor.
 11. UL listed.
- E. Minimum requirements for combination starters / disconnect switch.
1. Non-fused UL 508 disconnect switch with lockable handle (locks not provided).
 2. Cover interlock.
 3. Adjustable motor overload with trip indication.
 4. Manual overload reset button (accessible without opening enclosure).
 5. 115-v fused secondary control trans- former (fuse included — fused primary and secondary over 50 amps).
 6. Hand/Off/Auto selector switch (accessible without opening enclosure).
 7. Separate 4-position terminal strip for remote H-O-A wiring.
 8. C series contactors.
 9. Horsepower rated for motor applications.
 10. NEMA 4X type non-metallic enclosures.
 11. Lug connections for field power wiring.
 12. Factory mounted, wired, and run tested with factory-supplied motor.
 13. UL listed.
- F. All air handling units, (constant volume or VAV), shall be furnished with variable frequency drives. For a complete description of requirements for Variable-Frequency Motor Controller: Comply with Section 262923 "Variable-Frequency Motor Controllers."
- G. Minimum requirements for variable-Frequency Motor Controller:
1. Manufactured Units: Pulse-width modulated; variable torque for Design A and Design B inverter-duty motors.
 2. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.
 3. Unit Operating Requirements:
 - a. Internal Adjustability:
 - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3) Acceleration: 0.1 to 999.9 seconds.
 - 4) Deceleration: 0.1 to 999.9 seconds.
 - 5) Current Limit: 30 to minimum of 150 percent of maximum rating.
 - b. Self-Protection and Reliability Features:
 - 1) Surge suppression.
 - 2) Loss of input signal protection.

- 3) Under- and overvoltage trips.
 - 4) Variable-frequency motor controller and motor-overload/overtemperature protection.
 - 5) Critical frequency rejection.
 - 6) Loss-of-phase protection.
 - 7) Reverse-phase protection.
 - 8) Motor-overtemperature fault.
- c. Bidirectional auto speed search.
 - d. Torque boost.
 - e. Motor temperature compensation at slow speeds.
- 1) Panel-mounted operator station.
 - 2) Historical logging information and displays.
 - 3) Digital indicating devices.
- f. Control Signal Interface: Electric.
 - g. Proportional Integral Directive (PID) control interface.
 - h. DDC system for HVAC Protocols for Network Communications: ASHRAE 135.
4. Line Conditioning:
- a. Input line conditioning.
 - b. Output filtering.
 - c. EMI/RFI filtering.

2.11 MATERIALS

A. Steel:

1. ASTM A 36/A 36M for carbon structural steel.
2. ASTM A 568/A 568M for steel sheet.

B. Stainless Steel:

1. Manufacturer's standard grade for casing.
2. Manufacturer's standard type, ASTM A 240/A 240M for bare steel exposed to airstream or moisture.

C. Galvanized Steel: ASTM A 653/A 653M.

D. Aluminum: ASTM B 209.

E. Corrosion Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B 117.

1. Standards:

- a. ASTM B 117 for salt spray.
- b. ASTM D 2794 for minimum impact resistance of 100 in-lb.

- c. ASTM B 3359 for cross hatch adhesion of 5B.
- 2. Application: Immersion or Spray.
- 3. Thickness: 1 mil.
- 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.12 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Air-handling units and their components shall be factory tested according to AHRI 430 and shall be listed and labeled by AHRI.
 - 1. AMCA 210 Compliance: Fan performance according to AMCA 210.
- B. AMCA 300 and AMCA 301, or AHRI 260 Certification: Air-handling unit fan sound ratings shall comply with AMCA 300, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data" and AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data," or with AHRI 260, "Sound Rating of Ducted Air Moving and Conditioning Equipment."
- C. Water Coils: Factory tested to 300 psig according to AHRI 410 and ASHRAE 33.
- D. Steam Coils: Factory tested to 300 psig, and to 200 psig underwater, according to AHRI 410 and ASHRAE 33.
- E. Refrigerant Coils: Factory tested to minimum 450-psig internal pressure, and to minimum 300-psig internal pressure while underwater, according to AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Replace with new insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting:

1. Install air-handling units on cast-in-place concrete equipment bases or on steel angle iron frame field fabricated as noted on plan. Comply with requirements for equipment bases and foundations specified in Section 033000 "Cast-in-Place Concrete." And Section 033053 "Miscellaneous Cast-in-Place Concrete."
 2. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- B. Suspended Units: Suspend and brace units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548.13 "Vibration Controls for HVAC."
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.3 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4, ASTM B 88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Hot- and Chilled-Water and Dual Temp Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping" and Section 232116 "Hydronic Piping Specialties." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

3.4 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 with a black background and engraved white letters at least 1/2 inch high.

3.5 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 - 2. Charge refrigerant coils with refrigerant and test for leaks.
 - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
- C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Verify that outdoor- and return-air mixing dampers open and close and maintain minimum outdoor-air setting.

7. Comb coil fins for parallel orientation.
8. Verify that proper thermal-overload protection is installed for electric coils.
9. Install new, clean filters.
10. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.8 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.9 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling unit and air-distribution systems, and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.10 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION

SECTION 23 81 27

DUCTLESS SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fan Coil Unit.
 - 2. Condensing unit.
 - 3. For units/systems up to five tons maximum.
- B. This applies to units less than 5 tons.

1.2 REFERENCES

- A. Air-Conditioning and Refrigeration Institute:
 - 1. ARI 210/240 - Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
 - 2. ARI 270 - Sound Rating of Outdoor Unitary Equipment.
 - 3. ARI 340/360 - Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment.
 - 4. ARI 365 - Commercial and Industrial Unitary Air-Conditioning Condensing Units.
- B. American Society of Heating, Refrigerating and Air-Conditioning Engineers:
 - 1. ASHRAE 52.1 - Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
 - 2. ASHRAE 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- C. ASTM International:
 - 1. ASTM B117 - Standard Practice for Operating Salt Spray (Fog) Apparatus.
- D. National Electrical Manufacturers Association:
 - 1. NEMA MG 1 - Motors and Generators.
- E. National Fire Protection Association:
 - 1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS

- A. Product Data: Submit data indicating:
 - 1. Cooling and heating capacities.
 - 2. Dimensions.
 - 3. Weights.
 - 4. Rough-in connections and connection requirements.
 - 5. Electrical requirements with electrical characteristics and connection requirements.
 - 6. Controls.
 - 7. Accessories.
- B. Manufacturer's Installation Instructions: Submit assembly, support details, connection requirements, and include start-up instructions.

1.4 QUALITY ASSURANCE

- A. Performance Requirements: Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90.1 when used in combination with compressors and evaporator coils when tested in accordance with ARI Standards.

PART 2 PRODUCTS

2.1 SPLIT SYSTEM AIR CONDITIONING UNITS

- A. Product Description: Split system consisting of fan coil unit and condensing unit including cabinet, evaporator fan, refrigerant cooling coil, compressor, refrigeration circuit, condenser, air filters, controls, air handling unit accessories, condensing unit accessories, and refrigeration specialties.
- B. Manufacturers:
 - 1. Daikin.
 - 2. Toshiba.
 - 3. Sanyo.
- C. Refrigerants R-410A.
- D. Unit shall be wall mounted, ceiling mounted, or ceiling cassette type (integral with grid).

2.2 CONDENSING UNIT

- A. General: Factory assembled and tested air-cooled condensing units, consisting of casing, compressors, condensers, coils, condenser fans and motors, and unit controls.

- B. Unit Casings: Exposed casing surfaces constructed of galvanized steel with manufacturer's standard baked enamel finish. Designed for outdoor installation and complete with weather protection for components and controls, and complete with removable panels for required access to compressors, controls, condenser fans, motors, and drives.
 - 1. Mounting feet shall be provided and shall be welded to the base of the cabinet and be of sufficient size to afford reliable equipment mount and stability.
 - 2. The fan grill shall be of ABS plastic.
 - 3. Cabinet mounting and construction shall be sufficient to withstand 155 MPH wind speed conditions for use in Hurricane condition areas. Mounting, base support, and other installation to meet Hurricane Code Conditions shall be by others.
- C. Compressor: DC twin-rotor rotary compressor with Variable Speed Inverter Drive Technology Or compressor shall be a Frame Compliant Scroll compressor with Variable Speed Inverter Drive Technology. Compressor shall five (5) year warranty.
 - 1 The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which shall result in significant energy savings.
 - 2 To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be automatically, intermittently applied to the compressor motor windings to maintain sufficient heat to vaporize any refrigerant. No crankcase heater is to be used.
 - 3 The outdoor unit shall have an accumulator and high-pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.
- A. Condenser Coil: Constructed of copper tubing mechanically bonded to copper fins, factory leak and pressure tested. Coil shall be coated with minimum 1.0 mil. aluminum impregnated polyurethane coating by Blygold PoluAl XT or approved equal. Coating shall withstand 4,000 hours in both salt spray test per ASTM B117 and acid salt spray test per ASTM D5339.
 - 1. Refrigerant flow from the condenser shall be controlled by means of an electronic linear expansion valve (LEV) metering device. The LEV shall be control by a microprocessor-controlled step motor.
 - 2. All refrigerant lines between outdoor and indoor units shall be of annealed, refrigeration grade copper tubing, ARC Type, meeting ASTM B280 requirements, individually insulated in twin-tube, flexible, closed-cell, CFC-free elastomeric material for the insulation of refrigerant pipes and tubes with thermal conductivity equal to or better than 0.27 BTU-inch/hour per Sq Ft / °F, a water vapor transmission equal to or better than 0.08 Perm-inch and superior fire ratings such that insulation will not contribute significantly to fire and up to 1" thick insulation shall have a - Flame-Spread Index of less than 25 and a Smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102.
 - 3. Refrigerant shall be R407C or R410A.

- B. Controls: Furnish operating and safety controls including high- and low-pressure cutouts. Control transformer. Furnish magnetic contactors for compressor and condenser fan motors.
- C. Condenser Fans and Drives: Direct drive propeller fans statically and dynamically balanced. Wired to operate with compressor. Permanently lubricated ball bearing type motors with built-in thermal overload protection. Furnish high efficiency fan motors.
 - 1. The fan blade(s) shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated.
 - 2. The outdoor unit shall have horizontal or vertical discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent external contact with moving parts.
- D. The outdoor unit shall be able to operate with a maximum height difference of 100 feet (30 meters) between indoor and outdoor units. System shall operate at up to a maximum refrigerant tubing length of 100 feet for the 18,000 BTU/h and 165 feet for the 24,000, 30,000, 36,000, and 42,000 BTU/h units between indoor and outdoor units without the need for line size changes, traps or additional oil. Units shall be pre-charged for a maximum of 1000 feet of refrigerant tubing.
- E. Condensing Unit Accessories: Furnish the following accessories:
 - 1. The outdoor unit shall be capable of cooling operation down to 0°F ambient temperature without additional low ambient controls (optional wind baffle shall be required).
 - 2. Time delay relay.
 - 3. Anti-short cycle timer.
 - 4. Disconnect switch.
 - 5. Vibration isolators.
 - 6. Hot gas bypass kit.
 - 7. Coil with corrosion resistant coating capable of withstanding salt spray test of 1000 hours in accordance with ASTM B117.
 - 8. Condenser Coil Guard: Condenser fan openings furnished with PVC coated steel wire safety guards.
 - 9. Suction and discharge pressure gauges.
- F. Refrigeration specialties: Furnish the following for each circuit:
 - 1. Charge of compressor oil.
 - 2. Holding charge of refrigerant.
 - 3. Replaceable core type filter drier.
 - 4. Liquid line sight glass and moisture indicator.

5. Shut-off valves on suction and liquid piping.
6. Liquid line solenoid valve.
7. Charging valve.
8. Oil level sight glass.
9. Crankcase heater.
10. Hot gas muffler.
11. Pressure relief device.

G. Electrical

- 1 The electrical power of the unit shall be 208volts or 230 volts, single phase, 60 hertz. The unit shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts.
- 2 Power for the indoor unit shall be supplied from the outdoor unit via Mitsubishi Electric A-Control using three (3) fourteen (14) gauge AWG conductors plus ground wire connecting the units.
- 3 The outdoor unit shall be controlled by the microprocessor located in the indoor unit.
- 4 The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC.
- 5 The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.

2.3 Indoor Units

A. General All Units

1. Filter: Return air shall be filtered by means of an easily removable, washable filter or disposable. An optional MERV 8 filter shall be furnished. Efficiency based on ASHRAE 52.1.
2. Coil: The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil. Provide an optional drain pan level switch designed to connect to the control board, shall be provided if required, and installed on the condensate pan to prevent condensate from overflowing. Provide An optional drain lift mechanism, capable of lifting condensate 23-5/8" above the drain pan, shall be provided.
3. Electrical: The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz. The system shall be capable of satisfactory operation within voltage limits of 187 volts to 253 volts. The power to the indoor unit shall be supplied from the outdoor unit using a three (3) conductor AWG-14 wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units.

4. Control: The control system shall consist of a minimum of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from a wireless or wired controller, providing emergency operation, and controlling the outdoor unit. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Indoor units shall have the ability to control supplemental heat via connector CN24 and a 12 VDC output.
5. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.
6. The Wired Remote Controller shall be approximately 5" x 5" in size and white in color with a light-green LCD display. There shall be a built-in weekly timer with up to 8 pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Auto/Fan/Dry mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature shall be displayed in either Fahrenheit (°F) or Celsius (°C), and Temperature changes shall be by increments of 1°F (0.5°C). Shall have the capability of controlling up to a maximum of 16 systems, as a group with the same mode and set point for all, at a maximum developed control cable distance of 1,500 feet.
7. The control voltage from the wired controller to the indoor unit shall be 12/24 volts, DC. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. Up to two wired controllers shall be able to be used to control one unit.

B. Ceiling Suspended Type

1. The Ceiling Suspended type indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the remote controller, shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry air before shipment from the factory.
2. The casing shall be ABS plastic and have a Munsell 6.4Y 8.9/0.4 white finish. Cabinet shall be designed for suspension mounting from above and horizontal operation. Indoor unit shall have removable mounting brackets. A mounting template with suspension bolt locations shall be furnished with indoor unit. Mounting bolts or threaded rod of 3/8" diameter shall be used to suspend unit and unit shall not require direct contact with ceiling or panel for proper operation. Mounting support shall be of sufficient strength and design to support full weight of indoor unit. The rear cabinet panel shall have knock-out provisions for a field installed filtered 4-5/16 diameter ventilation air intake connection.
3. The indoor unit fan shall have multiple high performance, double inlet, forward curve sirocco fans driven by a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of four (4) speeds: Low, M1, M2, and Hi plus AUTO fan setting. The fan shall have

a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set point and sensed space temperature.

4. Vane: There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall provide a choice of five (5) vertical airflow patterns selected by remote control: 100% horizontal flow, 80% horizontal flow (plus 20% downward airflow), 60% horizontal airflow (plus 40% downward airflow), 40% horizontal airflow (plus 60% downward airflow), and swing. The horizontal vane shall significantly decrease downward air resistance for lower sound levels and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.

C. Ducted Type

1. The Ducted type indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the wired or wireless wall-mounted controller, shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry air before shipment from the factory.
2. The cabinet shall be space saving, low profile, horizontal, ducted type. Formed cabinet shall be constructed of G-60 galvanized steel with factory applied foam surface insulation to prevent condensation on outer surfaces. The cabinet shall be provided with four mounting brackets to accommodate suspension from threaded rod or structural support located on the side panels in all four corners. Brackets shall be suitable for supporting the weight of the indoor unit. The indoor unit cabinet shall be equipped with a ducted air outlet and ducted rear return air connection. units shall support an optional Bottom Return Adaptor. units shall have selectable rear or bottom return as a standard feature. The units shall be equipped with a 3-15/16" diameter ventilation air intake knock-out.
3. The indoor unit fan unit shall be an assembly with two (2) or four (4) Sirocco fans direct driven by a single motor. Fan shall develop airflow to deliver up to 0.20 - 0.60 inches wg of external static pressure. The indoor fans shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings. The indoor fans shall operate on any of three (3) speeds, High, Mid, Low and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set point and space temperature.

D. Wall Mounted Type

1. The indoor unit shall be factory assembled, wired, and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor. The unit, in conjunction with the wired wall-mounted, wireless wall-mounted or wireless handheld controller, shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry air before shipment from the factory.
2. Unit Cabinet: The cabinet shall be formed from high strength molded plastic with smooth finish, flat front panel design with access for filter. Cabinet color shall be white – Munsell

1.0Y 9.2/0.2. The unit shall be wall mounted by means of a factory supplied, pre-drilled, mounting plate.

3. The indoor unit fan shall be high performance, double inlet, forward curve, direct drive sirocco fan with a single motor. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. The indoor fan shall consist of three (3) speeds: Low, Mid, and Hi and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set point and space temperature.
4. There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall significantly decrease downward air resistance for lower sound levels and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement.

E. Ceiling Recessed

1. The indoor unit shall be a space-saving ceiling-recessed cassette type, factory assembled, wired, and tested. Contained within the unit shall be all factory wiring and internal piping, drain left mechanism, control circuit board, fan, and fan motor. The unit, in conjunction with the remote controller, shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry air before shipment from the factory.
2. The cabinet shall be formed from galvanized sheet metal coated with high-density foam insulation. Cabinet shall be for recessed mounting and provided with four (4) corner mounting supports behind removable corner pockets in Grille assembly allowing adjustment of mounting height from front of unit. The cabinet panel shall have provisions for a field installed filtered outside air intake. There shall be a knock-out to provide a branch air duct for conditioning a secondary space. There shall be an optional multi-function casement which will mount between the unit cabinet and the Grille assembly to provide a second field installed filtered outside air intake and provide a mount for a high-efficiency filter element.
3. A separate grill assembly shall be attached to the front of the cabinet to provide supply air vanes in four directions and a center mounted return air section. The four-way grill shall be fixed to bottom of cabinet allowing two, three or four-way blow. The grill vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space. Grill assembly color shall be white.
4. The indoor fan shall be an assembly with a turbo fan propeller, direct driven by a single motor and shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings. The indoor fan shall consist of four (4) speed settings, Low, Med1, Med2, High and Auto. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set point and space temperature.
5. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow with switches that can be set to provide optimum airflow based on ceiling height and number of outlets used. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up

and down for uniform air distribution. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space. If specified, the grill shall have an optional sensor kit installed – sensor function described in System Control Section.

PART 3 EXECUTION

3.1 INSTALLATION – FAN COIL UNIT

- A. Install per manufacturer's recommendations. Where appropriate, provide 2" deflection spring vibration isolators and seismic restraints.
- B. Install condensate piping with trap and route from drain pan to approved receptor with indirect connection.

3.2 TRAINING

- A. Training shall include minimum of 10 LAWA personnel for 40 hours three shifts total, 16 hours shall be classroom training and 24 hours shall be hands on training.

END OF SECTION

SECTION 23 81 29

VRF HEAT PUMP 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 complete VRF HVAC system(s) including, but not limited to the following components to make a complete operating system(s) according to requirements indicated:
 - 1. Indoor, exposed, wall-mounted units.
 - 2. Outdoor air source heat pumps
 - 3. System controls
 - 4. System refrigerant
 - 5. System refrigerant piping.
 - 6. Metal hangers and supports.
 - 7. Metal framing systems.
 - 8. Fastener systems.
 - 9. Pipe stands.
 - 10. Miscellaneous support materials.
 - 11. Piping and tubing insulation.
 - 12. System control cable and raceways.

1.3 DEFINITIONS

- A. Air-Conditioning System Operation: System capable of operation with all zones in cooling only.
- B. Heat-Pump System Operation: System capable of operation with all zones in either heating or cooling, but not with simultaneous heating and cooling zones that transfer heat between zones.
- C. Heat Recovery System Operation: System capable of operation with simultaneous heating and cooling zones that transfer heat between zones.
- D. HRCU: Heat Recovery Control Unit. HRCUs are used in heat recovery VRF HVAC systems to manage and control refrigerant between indoor units to provide simultaneous heating and cooling zones. "Heat Recovery Control Unit" is the term used by ASHRAE for what different manufacturers term as branch circuit controller,

branch selector box, changeover box, flow selector unit, mode change unit, and other such terms.

- E. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- F. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.
- G. Two-Pipe System Design: One refrigerant vapor line and one refrigerant liquid line connect a single outdoor unit or multiple manifold outdoor units in a single system to associated system HRCUs. One refrigerant liquid line and refrigerant vapor line connect HRCUs to associated indoor units. HRCUs used in two pipe systems act as an intermediate heat exchanger and include diverting valves and gas/liquid separators to move high- and low-pressure refrigerant between indoor units.
- H. VRF: Variable refrigerant flow.

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 indoor and outdoor units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include operating performance at design conditions and at extreme maximum and minimum outdoor ambient conditions.
 - 4. Include description of system controllers, dimensions, features, control interfaces and connections, power requirements, and connections.
 - 5. Include system operating sequence of operation in narrative form for each unique indoor- and outdoor-unit control.
 - 6. Include description of control software features.
 - 7. Include total refrigerant required and a comprehensive breakdown of refrigerant required by each system installed.
 - 8. Include refrigerant type and data sheets showing compliance with requirements indicated.
 - 9. For system design software.
 - 10. Indicate location and type of service access.
- B. Sustainable Design Submittals:
 - 1. Product Data for EA Prerequisite "Minimum Energy Performance": Indicating compliance with minimum energy performance requirements.
 - 2. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
 - 3. ASHRAE/IES 90.1 compliance.
 - 4. Product Data for EA Credit "Enhanced Refrigerant Management": Indicating that products meet requirements for refrigerant management.

C. Shop Drawings: For VRF HVAC systems.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. 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 and details of refrigerant piping and tubing showing installation requirements for manufacturer-furnished divided flow fittings.
5. Include diagrams for power, signal, and control wiring.

D. Samples for Initial Selection: For fully and partially exposed indoor units with factory finishes viewable by occupants.

1. Include a Sample for each unique finish with unit identification, detailed description of application, and cross-referenced floor plans showing locations.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, sections, and 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 floors, roofs and associated members to which equipment, piping, ductwork, cables, and conduit will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Wall-mounted controllers located in finished space showing relationship to light switches, fire-alarm devices, and other installed devices.
5. Size and location of access doors and panels installed behind walls and inaccessible ceilings for products installed behind walls and requiring access.
6. Items penetrating finished ceiling including the following:
 - a. Luminaires.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Service access panels.
 - f. Fire alarm devices

B. Qualification Data:

1. For Installer: Certificate from VRF HVAC system manufacturer certifying that Installer has successfully completed prerequisite training administered by manufacturer for proper installation of systems, including but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.

- a. Retain copies of Installer certificates on-site and make available on request.
- 2. For VRF HVAC system manufacturer.
- 3. For VRF HVAC system provider.
- C. Product Test Reports: Where tests are required, for each product, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Sample Warranties: For manufacturer's warranties.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For VRF HVAC systems 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 CD or DVD, USB media, or approved cloud storage platform, 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. Filters:
 - a. One set(s) for each unit with replaceable filters.
 - b. One set(s) for each unit type and unique size of washable filters.
 - 2. Indoor Units: One for each unique size and type installed.
 - 3. Controllers for Indoor Units: One for each unique controller type installed.
 - 4. Insert maintenance material requirements.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Nationally recognized manufacturer of VRF HVAC systems and products.
 - 2. Shipped VRF HVAC systems with similar requirements to those indicated for a continuous period of five years within time of bid.

3. VRF HVAC systems and products that have been successfully tested and in use on at least five completed projects.
 4. Having complete published catalog literature, installation, and operation and maintenance manuals for all products intended for use.
 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for system installation training, startup, commissioning, and troubleshooting of installations.
 - e. Owner training.
- B. Factory-Authorized Service Representative Qualifications:
1. Authorized representative of, and trained by, VRF HVAC system manufacturer.
 2. Demonstrated past experience with products being installed for period within three consecutive years before time of bid.
 3. Demonstrated past experience on five projects of similar complexity, scope, and value.
 - a. Each person assigned to Project shall have demonstrated past experience.
 4. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
 5. Service and maintenance staff assigned to support Project during warranty period.
 6. VRF HVAC system manufacturer's backing to take over execution of Work if necessary, to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.
- C. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by VRF HVAC system manufacturer.
1. Each employee shall be certified by manufacturer for proper installation of systems, including, but not limited to, equipment, piping, controls, and accessories indicated and furnished for installation.
 2. Installer certification shall be valid and current for duration of Project.
 3. Retain copies of Installer certificates on-site and make available on request.
 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.
- D. ISO Compliance: System equipment and components furnished by VRF HVAC system manufacturer shall be manufactured in an ISO 9001 and ISO 14001 facility.

1.9 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.

1.10 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace equipment and components that fail(s) in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures.
 - b. Faulty operation.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
 - d. .
 - 2. Warranty Period:
 - a. For Compressor: Five year(s) from date of Substantial Completion.
 - b. For Parts, Including Controls: Five year(s) from date of Substantial Completion.
 - c. For Labor: Five year(s) 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. Carrier Corporation /Toshiba.
2. Daikin AC (Americas), Inc.
3. Fujitec America, Inc.
4. LG Electronics.
5. Samsung HVAC.

B. Source Limitations: Obtain products from single source from single manufacturer including, but not limited to, the following:

1. Indoor and outdoor units, including accessories.
2. Controls and software.
3. HRCUs.
4. Refrigerant isolation valves.
5. Specialty refrigerant pipe fittings.

2.2 SYSTEM DESCRIPTION

A. Direct-expansion (DX) VRF HVAC system(s) with variable capacity in response to varying cooling and heating loads. System shall consist of multiple indoor units, outdoor unit(s), piping, controls, and electrical power to make complete operating system(s) complying with requirements indicated.

1. Two-pipe system design.
2. System(s) operation, heat pump as indicated on Drawings.
3. Each system with one refrigerant circuit shared by all indoor units connected to system.

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. AHRI Compliance: System and equipment performance certified according to AHRI 1230 and products listed in AHRI directory.

D. ASHRAE Compliance:

1. ASHRAE 15: For safety code for mechanical refrigeration.
2. ASHRAE 62.1: For indoor air quality.
3. ASHRAE 135: For control network protocol with remote communication.
4. ASHRAE/IES 90.1 Compliance: For system and component energy efficiency.

E. UL Compliance: Comply with UL 1995.

2.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer or specialist, as defined in Section 014000 "Quality Requirements," to design complete and operational VRF HVAC system(s) complying with requirements indicated.

1. Provide system refrigerant calculations.
 - a. Refrigerant concentration limits shall be within allowable limits of ASHRAE 15 and governing codes.
 - b. Indicate compliance with manufacturer's maximum vertical and horizontal travel distances. Prepare a comparison table for each system showing calculated distances compared to manufacturer's maximum allowed distances.
 2. Include a mechanical ventilation system and gas detection system as required to comply with ASHRAE 15 and governing codes.
 3. System Refrigerant Piping and Tubing:
 - a. Arrangement: Arrange piping to interconnect indoor units and outdoor unit(s) in compliance with manufacturer requirements and requirements indicated.
 - b. Routing: Conceal piping above ceilings and behind walls to maximum extent possible.
 - c. Sizing: Size piping system, using a software program acceptable to manufacturer, to provide performance requirements indicated. Consider requirements to accommodate future change requirements.
 4. System Controls:
 - a. Network arrangement.
 - b. Network interface with other building systems.
 - c. Product selection.
 - d. Sizing.
- B. Service Access:
1. Provide and document service access requirements.
 2. Locate equipment, system isolation valves, and other system components that require service and inspection in easily accessible locations. Avoid locations that are difficult to access if possible.
 3. Where serviceable components are installed behind walls and above inaccessible ceilings, provide finished assembly with access doors or panels to gain access. Properly size the openings to allow for service, removal, and replacement.
 4. If less than full and unrestricted access is provided, locate components within an 18-inch reach of the finished assembly.
 5. Where ladder access is required to service elevated components, provide an installation that provides for sufficient access within ladder manufacturer's written instructions for use.
 6. Comply with OSHA regulations.
- C. System Design and Installation Requirements:
1. Design and install systems indicated according to manufacturer's recommendations and written instructions.

2. Where manufacturer's requirements differ from requirements indicated, contact Architect for direction. The most stringent requirements should apply unless otherwise directed in writing by Architect.
 - D. Isolation of Equipment: Provide isolation valves to isolate each indoor unit and outdoor unit for service, removal, and replacement without interrupting system operation.
 - E. System Capacity Ratio: The sum of connected capacity of all indoor units shall be within the following range of outdoor unit rated capacity:
 1. Not less than 60 percent.
 2. Not more than 130 percent.
 3. Range acceptable to manufacturer.
 - F. System Turndown: Stable operation down to 20 percent of outdoor-unit capacity.
 - G. System Auto Refrigerant Charge: Each system shall have an automatic refrigerant charge function to ensure the proper amount of refrigerant is installed in system.
 - H. Outdoor Conditions:
 1. Suitable for outdoor ambient conditions encountered.
 - a. Design equipment and supports to withstand snow and ice loads of governing code and ASCE/SEI 7.
 - b. Provide corrosion-resistant coating for components and supports where located in coastal or industrial climates that are known to be harmful to materials and finishes.
 2. Maximum System Operating Outdoor Temperature: See Drawings.
 - I. Sound Performance: Sound levels generated by operating HVAC equipment shall be within requirements indicated.
 1. Indoor: Within design guidelines of "2015 ASHRAE HANDBOOK- HVAC Applications."
 - J. Thermal Movements: Allow for controlled thermal movements from ambient, surface, and system temperature changes.
 - K. Capacities and Characteristics: As indicated on Drawings.
- 2.4 INDOOR, EXPOSED, WALL-MOUNTED UNITS
- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
 - B. Cabinet:

1. Material: Painted steel, or coated steel frame covered by a plastic cabinet, with an architectural acceptable finish suitable for tenant occupancy on exposed surfaces.
2. Insulation: Manufacturer's standard internal insulation, complying with ASHRAE 62.1, to provide thermal resistance and prevent condensation.
3. Mounting: Manufacturer-designed provisions for field installation.
4. Internal Access: Removable panels of adequate size for field access to internal components for inspection, cleaning, service, and replacement.

C. DX Coil Assembly:

1. Coil Casing: Aluminum, galvanized, or stainless steel.
2. Coil Fins: Aluminum, mechanically bonded to tubes, with arrangement required by performance.
3. Coil Tubes: Copper, of diameter and thickness required by performance.
4. Expansion Valve: Electronic modulating type with linear or proportional characteristics.
5. Unit Internal Tubing: Copper tubing with brazed joints.
6. Unit Internal Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
7. Field Piping Connections: Manufacturer's standard.
8. Factory Charge: Dehydrated air or nitrogen.
9. Testing: Factory pressure tested and verified to be without leaks.

D. Drain Assembly:

1. Pan: Non-ferrous material, with bottom sloped to low point drain connection.
2. Condensate Removal: Gravity.
 - a. If a floor drain is not available at unit, provide unit with field-installed condensate pump accessory.
3. Field Piping Connection: Non-ferrous material with threaded NPT.

E. Fan and Motor Assembly:

1. Fan(s):
 - a. Direct-drive arrangement.
 - b. Single or multiple fans connected to a common motor shaft and driven by a single motor.
 - c. Fabricated from non-ferrous components or ferrous components with corrosion protection finish.
 - d. Wheels statically and dynamically balanced.
2. Motor: Brushless dc or electronically commutated with permanently lubricated bearings.
3. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.

4. Speed Settings and Control: Two (low, high), three (low, medium, high), or more than three speed settings or variable speed with a speed range of least 50 percent.
 5. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Filter Assembly:
1. Access: Front, to accommodate filter replacement without the need for tools.
 2. Efficiency: merv7
 3. Washable Media: Manufacturer's standard filter with antimicrobial treatment.
- G. Grille Assembly: Manufacturer's standard discharge grille with field-adjustable air pattern mounted in top or front face of unit cabinet.
- H. Unit Accessories:
1. Remote Room Temperature Sensor Kit: Wall-mounted, hardwired room temperature sensor kit for use in rooms that do not have room temperature measurement.
 2. Condensate Pump: Integral reservoir and control with electrical power connection through unit power.
- I. Unit Controls:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
 2. Factory-Installed Controller: Configurable digital control.
 3. Factory-Installed Sensors: Unit inlet air temperature Coil leaving refrigerant temperature.
 4. Field-Customizable I/O Capability:
 - a. Analog Inputs: Two for use in customizable control strategies.
 - b. Digital Inputs: Two for use in customizable control strategies.
 - c. Digital Outputs: Two for use in customizable control strategies.
 5. Features and Functions: Self-diagnostics, time delay, auto-restart, auto operation mode, manual operation mode, filter service notification, drain assembly high water level safety shutdown and notification, run test switch.
 6. Communication: Network communication with other indoor units and outdoor unit(s).
 7. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
 8. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
- J. Unit Electrical:
1. Enclosure: Manufacturer's standard, and suitable for indoor locations.
 2. Field Connection: Single point connection to power entire unit and integral controls.
 3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.

4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

2.5 OUTDOOR, AIR-SOURCE HEAT-PUMP UNITS

- A. Description: Factory-assembled and -tested complete unit with components, piping, wiring, and controls required for mating to piping, power, and controls field connections.
1. Specially designed for use in systems with either all heating or all cooling demands, but not for use in systems with simultaneous heating and cooling.
 2. Systems shall consist of one unit, or multiple unit modules that are designed by variable refrigerant system manufacturer for field interconnection to make a single refrigeration circuit that connects multiple indoor units.
 3. All units installed shall be from the same product development generation.
- B. Cabinet:
1. Galvanized steel and coated with a corrosion-resistant finish.
 - a. Coating with documented salt spray test performance of 1000 hours according to ASTM B117 surface scratch test (SST) procedure.
 2. Mounting: Manufacturer-designed provisions for field installation.
 3. Internal Access: Removable panels or hinged doors of adequate size for field access to internal components for inspection, cleaning, service, and replacement.
- C. Compressor and Motor Assembly:
1. One or more positive-displacement, direct-drive and hermetically sealed scroll compressor(s) with inverter drive and turndown to 15 percent of rated capacity.
 2. Protection: Integral protection against the following:
 - a. High refrigerant pressure.
 - b. Low oil level.
 - c. High oil temperature.
 - d. Thermal and overload.
 - e. Voltage fluctuations.
 - f. Phase failure and phase reversal.
 - g. Short cycling.
 3. Speed Control: Variable to automatically maintain refrigerant suction and condensing pressures while varying refrigerant flow to satisfy system cooling and heating loads.
 4. Vibration Control: Integral isolation to dampen vibration transmission.

5. Oil management system to ensure safe and proper lubrication over entire operating range.
 6. Crankcase heaters with integral control to maintain safe operating temperature.
 7. Fusible plug.
- D. Condenser Coil Assembly:
1. Plate Fin Coils:
 - a. Casing: Aluminum, galvanized, or stainless steel.
 - b. Fins: Aluminum or copper, mechanically bonded to tubes, with arrangement required by performance.
 - c. Tubes: Copper, of diameter and thickness required by performance.
 2. Aluminum Microchannel Coils:
 - a. Series of flat tubes containing a series of multiple, parallel flow microchannels layered between refrigerant header manifolds.
 - b. Single- or multiple-pass arrangement.
 - c. Construct fins, tubes, and header manifolds of aluminum alloy.
 3. Coating: Corrosion resistant.
 4. Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- E. Condenser Fan and Motor Assembly:
1. Fan(s): Propeller type.
 - a. Direct-drive arrangement.
 - b. Fabricated from non-ferrous components or ferrous components with corrosion protection finish to match performance indicated for condenser coil.
 - c. Statically and dynamically balanced.
 2. Fan Guards: Removable safety guards complying with OSHA regulations. If using metal materials, coat with corrosion-resistant coating to match performance indicated for condenser coil.
 3. Motor(s): Brushless dc or electronically commutated with permanently lubricated bearings and rated for outdoor duty.
 4. Motor Protection: Integral protection against thermal, overload, and voltage fluctuations.
 5. Speed Settings and Control: Variable speed with a speed range of least 75 percent.
 6. Vibration Control: Integral isolation to dampen vibration transmission.
- F. Drain Pan: If required by manufacturer's design, provide unit with non-ferrous drain pan with bottom sloped to a low point drain connection.
- G. Unit Controls:

1. Enclosure: Manufacturer's standard, and suitable for unprotected outdoor locations.
2. Factory-Installed Controller: Configurable digital control.
3. Factory-Installed Sensors:
 - a. Refrigerant suction temperature.
 - b. Refrigerant discharge temperature.
 - c. Outdoor air temperature.
 - d. Refrigerant high pressure.
 - e. Refrigerant low pressure.
 - f. Oil level.
4. Features and Functions: Self-diagnostics, time delay, auto-restart, fuse protection, auto operation mode, manual operation mode.
5. Communication: Network communication with indoor units and other outdoor unit(s).
6. Cable and Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
7. Field Connection: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.

H. Unit Electrical:

1. Enclosure: Metal, similar to enclosure, and suitable for unprotected outdoor locations.
2. Field Connection: Single point connection to power entire unit and integral controls.
3. Disconnecting Means: Factory-mounted circuit breaker or switch, complying with NFPA 70.
4. Control Transformer: Manufacturer's standard. Coordinate requirements with field power supply.
5. Wiring: Manufacturer's standard with each connection labeled and corresponding to a unit-mounted wiring diagram.
6. Raceways: Enclose line voltage wiring in metal raceways to comply with NFPA 70.

- I. Unit Hardware: Zinc-plated steel, or stainless steel. Coat exposed surfaces with additional corrosion-resistant coating if required to prevent corrosion when exposed to salt spray test for 1000 hours according to ASTM B117.

J. Unit Piping:

1. Unit Tubing: Copper tubing with brazed joints.
2. Unit Tubing Insulation: Manufacturer's standard insulation, of thickness to prevent condensation.
3. Field Piping Connections: Manufacturer's standard.
4. Factory Charge: Dehydrated air or nitrogen.
5. Testing: Factory pressure tested and verified to be without leaks.

2.6 SYSTEM CONTROLS

A. General Requirements:

1. Network: Indoor units and outdoor units shall include integral controls and connect through a TIA-485A or manufacturer-selected control network.
2. Network Communication Protocol: Manufacturer proprietary or open control communication between interconnected units.
3. Integration with Building Automation System: ASHRAE 135, BACnet IP and certified by BACnet Testing Lab (BTL), including the following:
 - a. Ethernet connection via RJ-45 connectors and port with transmission at 100 Mbps or higher.
 - b. Integration devices shall be connected to local uninterruptible power supply unit(s) to provide at least 5 minutes of battery backup operation after a power loss.
 - c. Integration shall include control monitoring scheduling.
4. Operator Interface:
 - a. Operators shall interface with system and unit controls through the following:
 - 1) Operator interfaces integral to controllers.
 - 2) Integration with Building Automation System.
 - b. Users shall be capable of interface with controllers for indoor units control to extent privileges are enabled. Control features available to users shall include the following:
 - 1) On/off control.
 - 2) Temperature set-point adjustment.
 - 3) Heating cooling change over

B. Central Controllers:

1. Centralized control for all indoor and outdoor units from a single central controller location.
 - a. Include multiple interconnected controllers as required.
2. Controls operation mode of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units. Operation modes available through central controller shall match those operation modes of controllers for indoor units.
3. Schedule operation of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
 - a. Sets schedule for daily, weekly, and annual events.
 - b. Schedule options available through central controller shall at least include the schedule options of controllers for indoor units.

4. Changes operating set points of indoor units as individual units, by selected groups of indoor units, or as collection of all indoor units.
5. Optimized start features to start indoor units before scheduled time to reach temperature set-point at scheduled time based on operating history.
6. Night setback feature to operate indoor units at energy-conserving heating and cooling temperature set-points during unoccupied periods.
7. Service diagnostics tool.
8. Able to disable and enable operation of individual controllers for indoor units.
9. Information displayed on individual controllers shall also be available for display through central controller.
10. Information displayed for outdoor units, including refrigerant high and low pressures.
11. Multiple RJ-45 ports for direct connection to a local PC and an Ethernet network switch.
12. Operator interface through a backlit, high-resolution color display touch panel.

C. Wired Controllers for Indoor Units:

1. Single controller capable of controlling multiple indoor units as group.
2. Auto Timeout Touch Screen LCD: Timeout duration shall be adjustable.
3. Multiple Language: English.
4. Temperature Units: Fahrenheit and Celsius.
5. On/Off: Turns indoor unit on or off.
6. Hold: Hold operation settings until hold is released.
7. Operation Mode: Cool, Heat, Auto, Dehumidification, Fan Only, and Setback.
8. Temperature Display: 1-degree increments.
9. Temperature Set-Point: Separate set points for Cooling, Heating, and Setback. Adjustable in 1-degree increments between.
10. Relative Humidity Display: 1 percent increments.
11. Relative Humidity Set-Point: Adjustable in 1 percent increments between.
12. Fan Speed Setting: Select between available options furnished with the unit.
13. Airflow Direction Setting: If applicable to unit, select between available options furnished with the unit.
14. Seven-day programmable operating schedule with up to five events per day. Operations shall include On/Off, Operation Mode, and Temperature Set-Point.
15. Auto Off Timer: Operates unit for an adjustable time duration and then turns unit off.
16. Occupancy detection.
17. Service Notification Display: "Filter".
18. Service Run Tests: Limit use by service personnel to troubleshoot operation.
19. Error Code Notification Display: Used by service personnel to troubleshoot abnormal operation and equipment failure.
20. User and Service Passwords: Capable of preventing adjustments by unauthorized users.
21. Setting stored in nonvolatile memory to ensure that settings are not lost if power is lost. Battery backup for date and time only.
22. Low-voltage power required for controller shall be powered through non-polar connections to indoor unit.

2.7 SYSTEM REFRIGERANT AND OIL

A. Refrigerant:

1. As required by VRF HVAC system manufacturer for system to comply with performance requirements indicated.
2. ASHRAE 34, Class A1 refrigerant classification.
3. R-410a.

B. Oil:

1. As required by VRF HVAC system manufacturer and to comply with performance requirements indicated.

2.8 SYSTEM CONDENSATE DRAIN PIPING

A. If more than one material is listed, material selection is Contractor's option.

B. Copper Tubing:

1. Drawn-Temper Tubing: According to ASTM B88, ASTM B88, Type M or according to ASTM B306.
2. Wrought-Copper Fittings: ASME B16.22.
3. Wrought-Copper Unions: ASME B16.22.
4. Solder Filler Metals: ASTM B32, lead-free alloys, and water-flushable flux according to ASTM B813.

C. CPVC plastic pipe according to ASTM F441/F441M, Schedule 40, with socket-type pipe fittings according to ASTM F438 and solvent cement according to ASTM F493.

D. PVC plastic pipe according to ASTM D1785, Schedule 40, with socket-type pipe fittings according to ASTM D2466 and solvent cement according to ASTM D2564, primer according to ASTM F656.

2.9 SYSTEM REFRIGERANT PIPING

A. Comply with requirements in Section 232300 "Refrigerant Piping" for system piping requirements.

B. Refrigerant Piping:

1. Copper Tube: ASTM B 88, Type L
2. Wrought-Copper Fittings: ASME B16.22.
3. Brazing Filler Metals: AWS A5.8/A5.8M.

C. Refrigerant Tubing Kits:

1. Furnished by VRF HVAC system manufacturer.
2. Factory-rolled and -bundled, soft-copper tubing with tubing termination fittings at each end.

3. Standard one-piece length for connecting to indoor units.
 4. Pre-insulated with flexible elastomeric insulation of thickness to comply with governing energy code and sufficient to eliminate condensation.
 5. Factory Charge: Dehydrated air or nitrogen.
- D. Divided-Flow Specialty Fittings: Where required by VRF HVAC system manufacturer for proper system operation, VRF HVAC system manufacturer shall furnish specialty fittings with identification and instructions for proper installation by Installer.
- E. Refrigerant Isolation Ball Valves:
1. Description: Uni-body full port design, rated for maximum system temperature and pressure, and factory tested under pressure to ensure tight shutoff. Designed for valve operation without removing seal cap.
 2. Seals: Compatible with system refrigerant and oil. Seal service life of at least 20 years.
 3. Valve Connections: Flare or sweat depending on size.

2.10 METAL HANGERS AND SUPPORTS

A. Copper Tube Hangers:

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

B. Plastic Pipe Hangers:

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

2.11 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. B-line, an Eaton business.
 - b. Flex-Strut Inc.
 - c. G-Strut.
 - d. Unistrut; Part of Atkore International.
2. Description: Shop- or field-fabricated, pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.

4. Channels: Continuous slotted steel channel with inturred lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of galvanized steel for use indoors and of stainless steel for use outdoors.
7. Metallic Coating for Use Indoors: Electroplated zinc, hot dip galvanized, or mill galvanized.
8. Plastic Coating for Use Outdoors: PVC.

2.12 FASTENER SYSTEMS

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

2.13 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 2. Base: Stainless steel.
 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- E. High-Type, Multiple-Pipe Stand:
 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 2. Bases: One or more; plastic.
 3. Vertical Members: Two or more protective-coated-steel channels.

4. Horizontal Member: Protective-coated-steel channel.
 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.14 MISCELLANEOUS SUPPORT MATERIALS

- A. Grout: ASTM C1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Non staining, noncorrosive, and nongaseous.
 2. Design Mix: 5000-psi, 28-day compressive strength.
- B. Structural Steel: ASTM A36/A36M, carbon-steel plates, shapes, and bars; galvanized.
- C. Threaded Rods: Continuously threaded. Zinc-plated steel or galvanized steel for indoor applications and stainless steel for outdoor applications. Mating nuts and washers of similar material as rods.

2.15 PIPING AND TUBING INSULATION

- A. Comply with requirements in Section 230719 "HVAC Piping Insulation" for system piping insulation requirements.
- B. Condensate Drain Piping and Tubing Insulation and Jacket Requirements:
1. Flexible Elastomeric Insulation:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - b. Indoors: 1/2 inch thick.
 - c. Outdoors: none
 2. Field-Applied Jacket:
 - a. Concealed: None required.
 - b. Indoors/ outdoors, Exposed to View: PVC, color selected by Architect, 20 mils thick.
- C. Refrigerant Tubing Insulation and Jacket Requirements:
1. Flexible Elastomeric Insulation:
 - a. Closed-cell, sponge- or expanded-rubber materials, complying with ASTM C534, Type I for tubular materials.
 - b. Indoors: 1 inch thick.
 - c. Outdoors: 1 inch thick.

2. Field-Applied Jacket:

- a. Concealed: None required.
- b. Indoors/outdoors, Exposed to View: PVC, color selected by Architect, 20 mils thick.

D. Flexible Elastomeric Insulation Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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."

E. PVC Jacket Adhesive: Compatible with PVC jacket.

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."

F. Metal Jacket Flashing Sealants:

1. Materials shall be compatible with insulation materials, jackets, and substrates.
2. Fire- and water-resistant, flexible, elastomeric sealant.
3. Service Temperature Range: Minus 40 to plus 250 deg F.
4. Color: Aluminum.
5. 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."

2.16 SYSTEM CONTROL CABLE

A. Cable Rating: Listed and labeled for application according to NFPA 70.

1. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262, by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.
 - a. Flame Travel Distance: 60 inches or less.
 - b. Peak Optical Smoke Density: 0.5 or less.
 - c. Average Optical Smoke Density: 0.15 or less.
2. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.
3. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

B. Low-Voltage Control Cabling:

1. Paired Cable: NFPA 70, Type CMG.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
 2. Lead Content: Less than 300 parts per million.
 3. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
 - a. One pair, twisted, No. 16 AWG, stranded (19x29) or No. 18 AWG, stranded (19x30) tinned-copper conductors as required by VRF HVAC system manufacturer.
 - b. PVC insulation.
 - c. Braided or foil shielded.
 - d. PVC jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: Comply with NFPA 262.
 4. Lead Content: Less than 300 parts per million.
- C. TIA-485A Network Cabling:
1. Standard Cable: NFPA 70, Type CMG.
 - a. Paired, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1685.
 2. Lead Content: Less than 300 parts per million.
 3. Plenum-Rated Cable: NFPA 70, Type CMP.
 - a. Paired, No. 22 AWG, stranded (7x30) tinned-copper conductors.
 - b. Fluorinated ethylene propylene insulation.
 - c. Unshielded.
 - d. Fluorinated ethylene propylene jacket.
 - e. NFPA 262 includes the standard flame-resistance test criteria in common use for cables and conductors.
 - f. Flame Resistance: NFPA 262.
 4. Lead Content: Less than 300 parts per million.
- D. Ethernet Network Cabling: TIA-568-C.2 Category 6 cable with RJ-45 connectors.

1. Description: Four-pair, balanced-twisted pair cable, certified to meet transmission characteristics of category cable indicated.
 2. Conductors: 100-ohm, 23 AWG solid copper.
 3. Lead Content: Less than 300 parts per million.
 4. Shielding: Shielded twisted pairs (FTP).
 5. Cable Rating: By application.
 6. Jacket: thermoplastic.
- E. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems" for control wiring and cable raceways.

2.17 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.
- E. Comply with Section 230546 "Coatings for HVAC" for corrosion-resistant coating.
- F. Corrosion-Resistant Coating: Coat with a corrosion-resistant coating capable of withstanding a 3000-hour salt-spray test according to ASTM B117.
1. Standards:
 - a. ASTM B117 for salt spray.
 - b. ASTM D2794 for minimum impact resistance of 100 in-lb.
 - c. ASTM B3359 for crosshatch adhesion of 5B.
 2. Application: Immersion or Spray.
 3. Thickness: 1 mil.
 4. Gloss: Minimum gloss of 60 on a 60-degree meter.

2.18 SOURCE QUALITY CONTROL

- A. Factory Tests: Test and inspect factory-assembled equipment.
- B. Equipment will be considered defective if it does not pass tests and inspections.

- C. Prepare test and inspection reports for historical record. Submit reports only if requested.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine products before installation. Reject products that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for piping and tubing to verify actual locations of connections before equipment installation.
- D. Examine roughing-in for wiring and conduit to verify actual locations of connections before equipment installation.
- E. Examine walls, floors, roofs, and outdoor pads for suitable conditions where equipment will be installed.
- F. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EQUIPMENT INSTALLATION, GENERAL

- A. Clearance:
 - 1. Maintain manufacturer's recommended clearances for service and maintenance.
 - 2. Maintain clearances required by governing code.
- B. Loose Components: Install components, devices, and accessories furnished by manufacturer, with equipment, that are not factory mounted.
 - 1. Loose components shall be installed by or system Installer under supervision of manufacturer's service representative.
- C. Equipment Restraint Installation: Install equipment with seismic-restraint device. Comply with requirements for seismic restraint under the building code

3.3 INSTALLATION OF INDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Unless otherwise required by VRF HVAC system manufacturer, support ceiling-mounted units from structure above using threaded rods; minimum rod size of 3/8 inch.

- C. Adjust supports of exposed and recessed units to draw units tight to adjoining surfaces.
- D. Protect finished surfaces of ceilings, floors, and walls that come in direct contact with units. Refinish or replaced damaged areas after units are installed.
- E. In rooms with ceilings, conceal piping and tubing, controls, and electrical power serving units above ceilings.
- F. In rooms without ceiling, arrange piping and tubing, controls, and electrical power serving units to provide a neat and finished appearance.
- G. For floor- and wall-mounted units that are exposed, conceal piping and tubing, controls, and electrical power serving units within walls.
- H. Attachment: Install hardware for proper attachment to supported equipment.

3.4 INSTALLATION OF OUTDOOR UNITS

- A. Install units to be level and plumb while providing a neat and finished appearance.
- B. Install outdoor units on support structures indicated on Drawings.
 - 1. Attachment: Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 2. Grouting: Place grout under equipment supports and make bearing surface smooth.
- C. Roof-Mounted Installations: Install outdoor units on equipment supports Anchor units to supports with removable, stainless-steel fasteners.

3.5 GENERAL REQUIREMENTS FOR PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping and tubing systems. Install piping and tubing as indicated unless deviations to layout are approved on coordination drawings.
- B. Install piping and tubing in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping and tubing at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping and tubing above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping and tubing to permit valve servicing.
- F. Install piping and tubing at indicated slopes.
- G. Install piping and tubing free of sags.

- H. Install fittings for changes in direction and branch connections.
- I. Install piping and tubing to allow application of insulation.
- J. Install groups of pipes and tubing parallel to each other, spaced to permit applying insulation with service access between insulated piping and tubing.
- K. Install sleeves and escutcheons for piping and tubing penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals and escutcheons for HVAC Piping."

3.6 INSTALLATION OF SYSTEM CONDENSATE DRAIN PIPING

- A. General Requirements for Drain Piping and Tubing:
 - 1. Install a union in piping at each threaded unit connection.
 - 2. Install an adjustable stainless-steel hose clamp with adjustable gear operator on unit hose connections. Tighten clamp to provide a leak-free installation.
 - 3. If required for unit installation, provide a trap assembly in drain piping to prevent air circulated through unit from passing through drain piping. Comply with more stringent of the following:
 - a. Details indicated on Drawings.
 - b. Manufacturer's requirements.
 - c. Governing codes.
 - d. In the absence of requirements, comply with requirements of ASHRAE handbooks.
 - 4. Extend drain piping from units with drain connections to drain receptors as indicated on Drawings. If not indicated on Drawings, terminate drain connection at nearest accessible location that is not exposed to view by occupants.
 - 5. Provide each 90-degree change in direction with a Y- or T-fitting. Install a threaded plug connection in the dormant side of fitting or future use as a service cleanout.
- B. Gravity Drains:
 - 1. Slope piping from unit connection toward drain termination at a constant slope of not less than two percent.
- C. Pumped Drains:
 - 1. If unit condensate pump or lift mechanism is not included with an integral check valve, install a full-size check valve in each branch pipe near unit connection to prevent backflow into unit.

3.7 INSTALLATION OF REFRIGERANT PIPING

- A. Refrigerant Tubing Kits:

1. Unroll and straighten tubing to suit installation. Deviations in straightness of exposed tubing shall be unnoticeable to observer.
 2. Support tubing using hangers and supports indicated at intervals not to exceed 5 feet <Insert dimension>. Minimum rod size, 1/4 inch.
 3. Prepare tubing ends and make mating connections to provide a pressure tight and leak-free installation.
- B. Install refrigerant piping according to ASHRAE 15 and governing codes.
- C. Select system components with pressure rating equal to or greater than system operating pressure.
- D. Install piping as short and direct as possible, with a minimum number of joints and fittings.
- E. Arrange piping to allow inspection and service of 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.
- F. Install refrigerant piping and tubing in protective conduit were installed belowground.
- G. Install refrigerant piping and tubing in rigid or flexible conduit in locations where exposed to mechanical damage.
- H. Unless otherwise required by VRF HVAC system manufacturer, slope refrigerant piping and tubing as follows:
1. Install horizontal hot-gas discharge piping and tubing with a uniform slope downward away from compressor.
 2. Install horizontal suction lines with a uniform slope downward to compressor.
 3. Install traps to entrain oil in vertical runs.
 4. Liquid lines may be installed level.
- I. When brazing, remove or protect components that could be damaged by heat.
- J. Before installation, clean piping, tubing, and fittings to cleanliness level required by VRF HVAC system manufacturer.
- K. Joint Construction:
1. Ream ends of tubes and remove burrs.
 2. Remove scale, slag, dirt, and debris from inside and outside of tube and fittings before assembly.
 3. Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper fittings with copper tubing.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze.

3.8 INSTALLATION OF METAL HANGERS AND SUPPORTS

- A. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.
- B. 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.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- D. Comply with MFMA-103 for metal framing system selections and applications that are not specified.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners, for use in lightweight concrete or concrete slabs less than 4 inches thick, in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
 - 3. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- 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.
 - 1. 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. Piping and Tubing Insulation:
 - 1. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - 2. 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.
- N. Horizontal-Piping Hangers and Supports: Install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated, stationary pipes NPS 1/2 to NPS 30.
 - 2. 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.
 - 3. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 - 4. Multiple horizontal pipes located indoors may use metal framing systems with split clamp attachment for each pipe in lieu of individual clevis hangers.
 - 5. Pipe stands for horizontal pipes located outdoors.
 - 6. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
 - 7. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.
- O. Horizontal Piping Hanger Spacing and Rod Size: Install hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
 - 1. Sizes through 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.
- P. Plastic Pipe Hanger and Support Spacing:
 - 1. Space hangers and supports according to pipe manufacturer's written instructions for service conditions.
 - 2. Maximum spacing, 5 feet; minimum rod size, 1/4 inch.
- Q. Vertical-Piping Clamps: Install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): If longer ends are required for riser clamps.
- R. Support vertical runs at roof, at each floor, and at midpoint intervals between floors, not to exceed 10 feet.
- S. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified.
- T. Use hangers, supports, and attachments with galvanized coatings unless otherwise indicated.
- U. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- V. Trim excess length of continuous-thread hanger and support rods to 1/2 inch.
- W. Hanger-Rod Attachments: Install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
 3. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 4. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.
- X. Building Attachments: 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-joint 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.
- 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.

3.9 INSTALLATION OF PIPING AND TUBING 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. Installation to maintain a continuous vapor barrier.
- B. 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.
- C. 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 unavailable, 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. 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.
- D. 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.

3.10 ELECTRICAL INSTALLATION

- A. Comply with requirements indicated on Drawings and in applicable Division 26 Sections.
- B. To extent electrical power is required for system equipment, components, and controls, and is not indicated on Drawings and addressed in the Specifications, the design for such electrical power shall be delegated to VRF HVAC system provider.

1. Delegated design of electrical power to equipment, components and controls, and associated installation shall be included at no additional cost to Owner.
 - C. Connect field electrical power source to each separate electrical device requiring field electrical power. Coordinate termination point and connection type with Installer.
 - D. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.
 - E. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding connections.
 - F. Install nameplate or acrylic label with self-adhesive back for each electrical connection indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate shall be laminated phenolic layers of black with engraved white letters. Letters at least 1/2 inch high.
 2. Locate nameplate or label where easily visible.
 - G. Comply with TIA-569-D for pull-box sizing and length of conduit and number of bends between pull points.
 - H. Install manufactured conduit sweeps and long-radius elbows if possible.
 - I. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- 3.11 INSTALLATION OF SYSTEM CONTROL CABLE
- A. Comply with NECA 1.
 - B. Installation Method:
 1. Install cables in raceways except as follows:
 - a. Within equipment and associated control enclosures.
 - b. In accessible ceiling spaces where open cable installation method may be used.
 - c. In gypsum board partitions where cable may be enclosed within wall cavity.
 2. Conceal raceway and cables except in unfinished spaces.
 - C. General Requirements for Cabling:
 1. Comply with TIA-568-C Series of standards.
 2. Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems."
 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 4. Cables may not be spliced and shall be continuous from terminal to terminal. Do not splice cable.

5. Cables serving a common system may be grouped in a common raceway. Install control cable in separate raceway from power wiring. Do not group conductors from different systems or different voltages.
6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
10. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems." Monitor cable pull tensions.
11. Support: Do not allow cables to lie on removable ceiling tiles or access panels.
12. Secure: Fasten securely in place with hardware specifically designed and installed to not damage cables.
13. Provide strain relief.
14. Keep runs short. Allow extra length for connecting to terminals.
15. Do not bend cables in a radius less than 10 times the cable OD.
16. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners and through penetrations.
17. Ground wire shall be copper, and grounding methods shall comply with IEEE C2. Demonstrate ground resistance.

D. Balanced Twisted-Pair Cable Installation:

1. Comply with TIA-568-C.2.
2. Do not untwist balanced twisted-pair cables more than 1/2 inch at the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 30 inches apart.
2. Cable shall not be run through or on structural members or in contact with pipes, ducts, or other potentially damaging items. Do not run cables between structural members and corrugated panels.

- F. Separation from EMI Sources: Comply with BICSI TDMM and TIA-569-D recommendations for separating unshielded cable from potential EMI sources including electrical power wiring and equipment.

3.12 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."

- C. Comply with BICSI TDMM, "Firestopping" Chapter.

3.13 GROUNDING INSTALLATION

- A. For data communication wiring, comply with TIA-607-B and with BICSI TDMM, "Bonding and Grounding (Earthing)" Chapter.
- B. For low-voltage control cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.14 IDENTIFICATION

- A. Identify system equipment, piping, tubing, and valves. Comply with requirements for identification specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.15 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage VRF HVAC system manufacturer's service representative to advise and assist installers; witness testing; and observe and inspect components, assemblies, and equipment installations, including controls and connections.
 - 1. Field service shall be performed by a factory-trained and -authorized service representative of VRF HVAC system manufacturer whose primary job responsibilities are to provide direct technical support of its products.
 - a. Additional factory-authorized representatives may assist with completion of certain activities only if supervised by manufacturer's employee. A factory-authorized representative shall not provide assistance without manufacturer's employee supervision.
 - 2. Manufacturer shall provide on-site visits during construction at installation milestones indicated. System Installer shall coordinate each visit in advance to give manufacturer sufficient notice to plan the visit.
 - a. First Visit: Kick-off meeting.
 - b. Second Visit: At approximately 25 percent completion of system(s).
 - c. Third Visit: At approximately 50 percent completion of system(s).
 - d. Fourth Visit: At approximately 75 percent completion of system(s).
 - e. Fifth Visit: Final inspection before system startup.
 - 3. Site Visits: Activities for each site visit shall include the following:
 - a. Meet with VRF HVAC system Installer to discuss field activities, issues, and suggested methods to result in a successful installation.
 - b. Offer technical support to Installer and related trades as related to VRF system(s) being installed.

- c. Review progress of VRF HVAC system(s) installation for strict compliance with manufacturer's requirements.
 - d. Advise and if necessary, assist Installer with updating related refrigerant calculations and system documentation.
 - e. Issue a report for each visit, documenting the visit.
 - 1) Report to include name and contact information of individual making the visit.
 - 2) Date(s) and time frames while on-site.
 - 3) Names and contact information of people meeting with while on-site.
 - 4) Clearly identify and list each separate issue that requires resolution. For each issue, provide a unique identification number, relevant importance, specific location or equipment identification, description of issue, recommended corrective action, and follow-up requirements needed. Include a digital photo for clarification if deemed to be beneficial.
4. Final Inspection before Startup:
- a. Before inspection, Installer to provide written request to manufacturer stating the system is fully installed according to manufacturer's requirements and ready for final inspection.
 - b. All system equipment and operating components shall be inspected. If components are inaccessible for inspection, they shall be made accessible before the final inspection can be completed.
 - c. Manufacturer shall provide a comprehensive inspection of all equipment and each operating component that comprise the complete system(s). Inspection shall follow a detailed checklist specific to each equipment and operating component.
 - d. Inspection reports for indoor units shall include, but not be limited to, the following:
 - 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low voltage reading(s) within an acceptable range.
 - 12) Controller type and model controlling unit.
 - 13) Controller location.
 - 14) Temperature settings and readings within an acceptable range.
 - 15) Humidity settings and readings within an acceptable range.
 - 16) Condensate removal acceptable.
 - 17) Fan settings and readings within an acceptable range.
 - 18) Unit airflow direction within an acceptable range.
 - 19) If applicable, fan external static pressure setting.

- 20) Filter type and condition acceptable.
 - 21) Noise level within an acceptable range.
 - 22) Refrigerant piping properly connected and insulated.
 - 23) Condensate drain piping properly connected and insulated.
 - 24) If applicable, ductwork properly connected.
 - 25) If applicable, external interlocks properly connected.
 - 26) Remarks.
- e. Inspection reports for outdoor units shall include, but not be limited to, the following:
- 1) Unit designation on Drawings.
 - 2) Manufacturer model number.
 - 3) Serial number.
 - 4) Network address, if applicable.
 - 5) Each equipment setting.
 - 6) Mounting, supports, and restraints properly installed.
 - 7) Proper service clearance provided.
 - 8) Wiring and power connections correct.
 - 9) Line-voltage reading(s) within acceptable range.
 - 10) Wiring and controls connections correct.
 - 11) Low voltage reading(s) within an acceptable range.
 - 12) Condensate removal acceptable.
 - 13) Noise level within an acceptable range.
 - 14) Refrigerant piping properly connected and insulated.
 - 15) Condensate drain piping properly connected and insulated.
 - 16) Remarks.
- f. Installer shall provide manufacturer with the requested documentation and technical support during inspection.
- g. Installer shall correct observed deficiencies found by the inspection.
- h. Upon completing the on-site inspection, manufacturer shall provide a written report with complete documentation describing each inspection step, the result, and any corrective action required.
- i. If corrective action is required by Installer that cannot be completed during the same visit, provide additional visits, as required, until deficiencies are resolved, and systems are deemed ready for startup.
- j. Final report shall indicate the system(s) inspected are installed according to manufacturer's requirements and are ready for startup.
- B. Perform the following tests and inspections with the assistance of manufacturer's service representative:
1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 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. Refrigerant Tubing Positive Pressure Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing installation, pressurize tubing systems to a test pressure of not less than 1.5 times VRF HVAC system operating pressure, but not less than 600 psig, using dry nitrogen.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of 24 hours. Allowance for pressure changes attributed to changes in ambient temperature are acceptable.
4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.
 - j. Outdoor temperature at end of test.
 - k. Remarks:
5. Submit test reports for Project record.

D. Refrigerant Tubing Evacuation Testing:

1. Comply with more stringent of VRF HVAC system manufacturer's requirements and requirements indicated.
2. After completion of tubing positive pressure testing, evacuate tubing systems to a pressure of 500 microns.
3. Successful testing shall maintain a test pressure for a continuous and uninterrupted period of one hour(s) with no change.
4. Prepare test report to record the following information for each test:
 - a. Name of person starting test, company name, phone number, and e-mail address.
 - b. Name of manufacturer's service representative witnessing test, company name, phone number, and e-mail address.
 - c. Detailed description of extent of tubing tested.
 - d. Date and time at start of test.
 - e. Test pressure at start of test.
 - f. Outdoor temperature at start of test.
 - g. Name of person ending test, company name, phone number, and e-mail address.
 - h. Date and time at end of test.
 - i. Test pressure at end of test.

- j. Outdoor temperature at end of test.
 - k. Remarks:
- 5. Submit test reports for Project record.
- 6. Upon successful completion of evacuation testing, system shall be charged with refrigerant.
- E. System Refrigerant Charge:
 - 1. Using information collected from the refrigerant tubing evacuation testing, system Installer shall consult variable refrigerant system manufacturer to determine the correct system refrigerant charge.
 - 2. Installer shall charge system following VRF HVAC system manufacturer's written instructions.
 - 3. System refrigerant charging shall be witnessed by system manufacturer's representative.
 - 4. Total refrigerant charge shall be recorded and permanently displayed at the system's outdoor unit.
- F. Products will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.16 STARTUP SERVICE

- A. Engage a VRF HVAC system manufacturer's service representative to perform system(s) startup service.
 - 1. Service representative shall be a factory-trained and -authorized service representative of VRF HVAC system manufacturer.
 - 2. Complete startup service of each separate system.
 - 3. Complete system startup service according to manufacturer's written instructions.
- B. Startup checks shall include, but not be limited to, the following:
 - 1. Check control communications of equipment and each operating component in system(s).
 - 2. Check each indoor unit's response to demand for cooling and heating.
 - 3. Check each indoor unit's response to changes in airflow settings.
 - 4. Check each indoor unit and outdoor unit for proper condensate removal.
 - 5. Check sound levels of each indoor and outdoor unit.
- C. Installer shall accompany manufacturer's service representative during startup service and provide manufacturer's service representative with requested documentation and technical support during startup service.
 - 1. Installer shall correct deficiencies found during startup service for reverification.
- D. System Operation Report:

1. After completion of startup service, manufacturer shall issue a report for each separate system.
2. Report shall include complete documentation describing each startup check, the result, and any corrective action required.
3. Manufacturer shall electronically record not less than two hours of continuous operation of each system and submit with report for historical reference.
 - a. All available system operating parameters shall be included in the information submitted.

E. Witness:

1. Invite Architect Owner and Commissioning Agent to witness startup service procedures.
2. Provide written notice not less than 20 business days before start of startup service.

3.17 ADJUSTING

- A. Adjust equipment and components to function smoothly and lubricate as recommended by manufacturer.
- B. Adjust initial temperature and humidity set points. Adjust initial airflow settings and discharge airflow patterns.
- C. Set field-adjustable switches and circuit-breaker trip ranges according to VRF HVAC system manufacturer's written instructions, and as indicated.
- D. 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.

3.18 PROTECTION

- A. Protect products from moisture and water damage. Remove and replace products that are wet, moisture damaged, or mold damaged.
- B. Protect equipment from physical damage. Replace equipment with physical damage that cannot be repaired to new condition. Observable surface imperfections shall be grounds for removal and replacement.
- C. Protect equipment from electrical damage. Replace equipment suffering electrical damage.
- D. Cover and seal openings of equipment to keep inside of equipment clean. Do not remove covers until finish work is complete.

3.19 MAINTENANCE SERVICE

- A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by manufacturer's authorized service representative. Include two service visits for preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper equipment and system operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

3.20 DEMONSTRATION

- A. Engage a VRF HVAC system manufacturer's employed training instructor or factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain entire system.
- B. Location: Owner shall provide a suitable on-site location to host classroom training.
- C. Training Attendees: Assume three people.
- D. Training Attendance: For record purposes, document training attendees at the start of each new training session. Record attendee's name, signature, phone number, and e-mail address.
- E. Training Format: Individual training modules shall include classroom training followed by hands-on field demonstration and training.
- F. Training Materials: Provide training materials in electronic format to each attendee.
 - 1. Include instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
 - 2. Video record each classroom training session and submit an electronic copy to Owner before requesting Owner acceptance of training.
- G. Acceptance: Obtain Architect, Commissioning Agent, or Owner written acceptance that training is complete, and requirements indicated have been satisfied.

END OF SECTION

SECTION 23 82 39.13

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. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
- C. 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. Indicate location and arrangement of integral controls.
 8. Wiring Diagrams: Power, signal, and control wiring.
- D. Samples: For each exposed product and for each color and texture specified.
- E. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

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. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 6. Perimeter moldings for exposed or partially exposed cabinets.
- B. 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.

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. Cabinet Unit-Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Provide products from one of the following:
 - 1. Daikin
 - 2. Modine
 - 3. Rittling
 - 4. Vulcan
 - 5. Sterling

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.
- C. Electric cabinet unit heaters shall comply with UL 2021.

2.3 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.4 COIL SECTION INSULATION

- A. Insulation Materials: ASTM C 1071; surfaces exposed to airstream shall have aluminum-foil facing to prevent erosion of glass fibers.
 - 1. Thickness: 1 inch.
 - 2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
 - 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
 - 4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
 - 5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2.5 CABINETS

- A. Material: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect or baked-enamel finish with manufacturer's custom paint, in color selected by Architect. Refer to schedule submit color chart for review and approval.
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. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch- thick galvanized sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
 3. Recessed Unit; Flanges: Steel, finished to match cabinet.
 4. Control Access Door: Key operated.
 5. Vertical, wall-mounted units. Base, minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches or 6 inches high with leveling bolts.
 6. Extended Piping Compartment: 8-inch- wide piping end pocket.
 7. Vertical Unit Accessories.
 - a. False Back: Minimum 0.0428-inch-thick steel, finished to match cabinet.
 - b. Outdoor-Air Wall Box: Minimum 0.1265-inch-thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen; aluminum louver with anodized finish in color selected by Architect from manufacturer's standard or custom colors.
 8. Outdoor-Air Damper: where indicated on plan shall be galvanized-steel blades with edge and end seals and nylon bearings; with electronic, two-position actuators. Review plans and schedules for the outdoor air dampers.

2.6 FILTERS

- A. Minimum Arrestance: And a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Pleated: 90 percent arrestance and MERV 7.

2.7 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.

2.8 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. Factory, Hot-Water Piping Package: ASTM B 88, Type L, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
1. Three-way, modulating control valve.
 2. Hose Kits: steel braided flexible connection, minimum 200-psig working pressure, and operating temperatures from 33 to 211 deg F Tag hose kits to equipment designations.
 - a. Length: 6"
 - b. Minimum Diameter: Equal to cabinet unit-heater connection size.
 3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout-proof stem.
 4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig working pressure, 250 deg F maximum operating temperature; with calibrated orifice or venturi, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
 5. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 threaded pipe and full-port ball valve in strainer drain connection.
 6. Wrought-Copper Unions: ASME B16.22.
- C. 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."
- D. DDC Terminal Controller:
1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
 2. Unoccupied Period Override: Two hours.
 3. Unit Supply-Air Fan Operations:
 - a. Occupied Periods: Fan runs continuously.
 - b. Unoccupied Periods: Fan cycles to maintain setback room temperature.
 4. Heating-Coil Operations:
 - a. Occupied Periods: Open control valve to provide heating if room temperature falls below thermostat set point.
 - b. Unoccupied Periods: Start fan and open control valve if room temperature falls below setback temperature.
 5. Optional Outdoor-Air Damper Operation: (not used)

- a. Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
 - b. Unoccupied Periods: Close damper.
 - 6. Controller shall have volatile-memory backup.
 - E. Interface with DDC System for HVAC Requirements:
 - 1. Terminal unit controller shall be by building DDC system manufacture. It can be field, or factory installed and shall be capable of at a minimum the following operation. Refer to the sequence of operation for full unit sequence and further requirements.
 - 2. 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.
 - F. Electrical Connection: Factory-wired motors and controls for a single field connection.
- 2.9 CAPACITIES AND CHARACTERISTICS.
- A. Capacities are as scheduled on plan.

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. vertical, wall-mounted cabinet unit heaters with wall boxes and outdoor-air intake louvers.
 - 1. 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; suspend from structure with elastomeric hangers.

- 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.
- E. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

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 to allow service and maintenance and access to valves and specialties.
- C. Connect piping to cabinet unit heater's factory, hot water piping package. Install the piping package if shipped loose.
- D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories." If applicable.
- E. Hot water and steam cabinet unit heaters shall comply with safety requirements in UL 1995.
- F. For hot water cabinet unit heaters, unless otherwise indicated, install union, strainer and 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."
- G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- H. 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. For electric units operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION

SECTION 23 82 39.16

PROPELLER 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 propeller unit heaters with hot-water coils.

1.3 DEFINITIONS

- A. CWP: Cold working pressure.
- B. PTFE: Polytetrafluoroethylene plastic.
- C. 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. Sustainable Design Submittals:
 - 1. Product data showing compliance with ASHRAE 62.1.
- C. 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. Indicate location and arrangement of integral controls.
8. 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 propeller 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. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Other equipment
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For propeller unit heaters to include in emergency, operation, and maintenance manuals.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Products shall be one of the following:
 1. Rattling
 2. Sterling
 3. Modine
 4. Vulcan

2.2 DESCRIPTION

- A. Assembly including casing, coil, fan, and motor in vertical and/or horizontal discharge configuration as scheduled with adjustable discharge louvers.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Electric propeller unit heaters shall comply with UL 2021.
- D. Explosion-proof electric propeller unit heaters shall comply with UL 823.

2.3 PERFORMANCE REQUIREMENTS

- A. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.4 HOUSINGS

- A. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

2.5 COILS

- A. General Coil Requirements: Test and rate hot-water and steam propeller unit-heater coils according to ASHRAE 33.
- B. Hot-Water Coil: Copper tube, minimum 0.025-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater.

2.6 FAN AND MOTOR

- A. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
- B. Motor: Permanently lubricated, multispeed. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.7 CONTROLS

- A. Control Devices:

1. Wall-mounted, fan-speed switch, and thermostat compatible with building temperature control system. Shall be line voltage and same manufacture as the building BMS.
2. Provide strap on "aquastat" on the HW supply line to prevent fan start up if hot water is not available.

2.8 CAPACITIES AND CHARACTERISTICS

- A. Heating Capacity are as scheduled or noted on plans.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive propeller 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 propeller unit heaters to comply with NFPA 90A.
- B. Install propeller unit heaters level and plumb.
- C. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers or spring hangers Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- 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. Drawings indicate general arrangement of piping, fittings, and specialties. Piping installation requirements are specified in the following Sections:
 1. Section 232113 "Hydronic Piping."
 2. Section 232116 "Hydronic Piping Specialties."
- B. Install piping adjacent to machine to allow service and maintenance.

- C. Connect piping to propeller unit heater's factory, hot water piping package. Install the piping package if shipped loose.
- D. For units, hot water coils shall comply with safety requirements in UL 1995.
- E. For hot water unit, unless otherwise indicated, install union and gate or ball valve and strainer on supply-water connection and union and calibrated balancing valve on return-water connection of propeller 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:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Adjust initial temperature set points.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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 DEFINITIONS

- A. VFC: Variable frequency controller.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

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 Company.
 - 2. Belden Inc.
 - 3. Cerro Wire LLC.
 - 4. Encore Wire Corporation.

5. General Cable Technologies Corporation.
 6. General Cable; General Cable Corporation.
 7. Senator Wire & Cable Company.
 8. Southwire Company.
- B. 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/THWN-2, Type XHHW-2 and Type SO.
- D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC mineral-insulated, metal-sheathed cable, Type MI and Type SO with ground wire.
- E. VFC Cable:
1. Comply with UL 1277, UL 1685, and NFPA 70 for Type TC-ER cable.
 2. Type TC-ER with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

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. 3M.
 2. AFC Cable Systems, Inc.
 3. Gardner Bender.
 4. Hubbell Power Systems, Inc.
 5. Ideal Industries, Inc.
 6. ILSCO.
 7. NSi Industries LLC.
 8. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 9. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.3 SYSTEM DESCRIPTION

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

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger, except VFC cable, which shall be extra flexible 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/THWN-2, single conductors in raceway or Mineral-insulated, metal-sheathed cable, Type MI.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway, Metal-clad cable, Type MC or Mineral-insulated, metal-sheathed cable, Type MI.
- 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/THWN-2, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway or Metal-clad cable, Type MC.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway or Type XHHW-2, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. VFC Output Circuits: Type TC-ER cable with braided shield.

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."

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 and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."
- B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.
 - a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - b. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

B. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.
 - 2. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For testing agency and testing agency's field supervisor.
- B. Field quality-control reports.

1.5 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.
- 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 UL 467 for grounding and bonding materials and equipment.

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. Burndy; Part of Hubbell Electrical Systems.
 2. ERICO International Corporation.
 3. Galvan Industries, Inc.; Electrical Products Division, LLC.
 4. Harger Lightning & Grounding.
 5. ILSCO.
 6. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 7. Siemens Power Transmission & Distribution, Inc.

2.2 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 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 in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 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.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 5/8 by 96 inches.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down; connect to horizontal bus.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.
- D. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.4 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
- C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

- D. Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.
- E. Metallic Fences: Comply with requirements of IEEE C2.
 - 1. Grounding Conductor: Bare, tinned copper, not less than No. 8 AWG.
 - 2. Gates: Shall be bonded to the grounding conductor with a flexible bonding jumper.
 - 3. Barbed Wire: Strands shall be bonded to the grounding conductor.

3.5 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. For grounding electrode system, install at least two rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install 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 tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- G. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
 - 1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
 - 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Tests and Inspections:
 - 1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 - 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 - 3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.

3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 4. Manhole Grounds: 10 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

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 the following:
 - a. Hangers.
 - b. Steel slotted support systems.
 - c. Trapeze hangers.
 - d. Clamps.
 - e. Turnbuckles.
 - f. Sockets.
 - g. Eye nuts.
 - h. Saddles.
 - i. Brackets.
 - 2. Include rated capacities and furnished specialties and accessories.
- B. Delegated-Design Submittal: For hangers and supports for electrical systems.
 - 1. Include design calculations and details of trapeze hangers.

1.4 INFORMATIONAL SUBMITTALS

- A. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M.
 - 2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4 factory-fabricated components for field assembly.
 - 1. Manufacturers: Subject to compliance with requirements, available 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, A Member of the ABB Group.
 - f. Unistrut; an Atkore International company.
 - 2. Material: Galvanized steel.
 - 3. Channel Width: 1-5/8 inches.
 - 4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for nonarmored electrical conductors or cables in riser conduits. Plugs 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. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Hilti, Inc.
 - 2) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti, Inc.
 - 4) ITW Ramset/Red Head; Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
 3. 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.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 6. Toggle Bolts: All-steel springhead type.
 7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems unless requirements in this Section are stricter.
- B. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- 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 in diameter.
- D. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 - 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- E. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 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, EMTs, IMCs, and RMCs may be supported by openings through structure members, according to NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. To Existing Concrete: Expansion anchor fasteners.
 - 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4

inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Section 055000 "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 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 as follows:
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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.

1.3 DEFINITIONS

- A. GRC: Galvanized rigid steel conduit.
- B. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.

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.
 - 3. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 - 4. Republic Conduit.
 - 5. Southwire Company.
 - 6. Thomas & Betts Corporation, A Member of the ABB Group.
 - 7. Western Tube and Conduit Corporation.
 - 8. Wheatland Tube Company.
- 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. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 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 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- I. Joint Compound for IMC or 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. Arnco Corporation.
 - 3. CANTEX INC.
 - 4. CertainTeed Corporation.
 - 5. Kraloy.
 - 6. RACO; Hubbell.
 - 7. Thomas & Betts Corporation, A Member of the ABB Group.
- 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 or tubing type and material.

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.; a division of Cooper Industries.
 - 2. Hoffman; a brand of Pentair Equipment Protection.
 - 3. MonoSystems, Inc.
 - 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and 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.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 SURFACE RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers 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. Hubbell Incorporated; Wiring Device-Kellems.
 - b. MonoSystems, Inc.
 - c. Legrand/Wiremold
 - d. Panduit

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. Cooper Technologies Company.
 - 2. EGS/Appleton Electric.
 - 3. Erickson Electrical Equipment Company.
 - 4. Hoffman; a brand of Pentair Equipment Protection.
 - 5. Hubbell Incorporated.
 - 6. MonoSystems, Inc.
 - 7. O-Z/Gedney; an EGS Electrical Group brand; an Emerson Industrial Automation business.
 - 8. RACO; Hubbell.
 - 9. Thomas & Betts Corporation, A Member of the ABB Group.
 - 10. Wiremold / Legrand.
- 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. Metal Floor Boxes:
 - 1. Material: Cast metal or sheet metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.

- 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- F. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- 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, galvanized, cast iron with gasketed cover.
- I. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- J. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- K. Gangable boxes are allowed.
- 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.
- M. Cabinets:
 - 1. NEMA 250, Type 1 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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.
- 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. NewBasis.
 - d. Oldcastle Precast, Inc.
 - e. Quazite: Hubbell Power Systems, Inc.
 - f. Synertech Moulded Products.
2. Standard: Comply with SCTE 77.
3. Configuration: Designed for flush burial with open 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 and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.7 SOURCE QUALITY CONTROL FOR UNDERGROUND ENCLOSURES

- A. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 1. Tests of materials shall be performed by an independent testing agency.
 2. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012 and traceable to NIST standards.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 1. Exposed Conduit: GRC or IMC.
 2. Concealed Conduit, Aboveground: GRC or IMC.
 3. Underground Conduit: RNC, Type EPC-40-PVC or Type EPC-80-PVC.
 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
 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, Not Subject to Severe Physical Damage: EMT.
 - 3. Exposed and Subject to Severe Physical Damage: GRC or IMC. Raceway locations include the following:
 - a. Loading dock.
 - b. Mechanical rooms.
 - 4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 6. Damp or Wet Locations: GRC or IMC.
 - 7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in damp or wet locations.
- C. Minimum Raceway Size: 3/4-inch trade size.
- 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 compression, steel or cast-metal fittings. Comply with NEMA FB 2.10.
 - 3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings.
- F. Install surface raceways only where indicated on Drawings.
- G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. 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 conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from RNC, Type EPC-40-PVC to GRC or IMC before rising above floor.
- J. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- 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. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- M. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. 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.
- O. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- P. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

Q. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches 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.

R. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.

S. 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 conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Where otherwise required by NFPA 70.

T. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

U. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
 - d. Attics: 135 deg F temperature change.
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific

location at time of installation. Install conduit supports to allow for expansion movement.

- V. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi recessed 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.
- W. 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 bottom of box unless otherwise indicated.
- X. 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.
- Y. Horizontally separate boxes mounted on opposite sides of walls, so they are not in the same vertical channel.
- Z. Locate boxes so that cover or plate will not span different building finishes.
- AA. 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.
- BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- CC. Set metal floor boxes level and flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
 - 1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 312000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
 - 2. Install backfill as specified in Section 312000 "Earth Moving."
 - 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 312000 "Earth Moving."
 - 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 of concrete for a minimum of 12 inches 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 from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
5. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
6. Underground Warning Tape: Comply with requirements in Section 260553 "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, below grade.
- 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.
- F. 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."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 44

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. 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 Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 1. Manufacturers: Subject to compliance with requirements, 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: Plastic.
 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. HOLDRITE.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- 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 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 annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:

1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- G. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.

1.3 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 electrical identification products.
- B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with ASME A13.1 and IEEE C2.
- B. Comply with NFPA 70.

- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Raceways and Cables Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- B. Raceways and Cables Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER - CONCEALED HIGH VOLTAGE WIRING."
- C. Warning labels and signs shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.3 LABELS

- A. Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label 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. Brady Corporation.
 - b. Champion America.
 - c. Emedco.
 - d. Grafoplast Wire Markers.
 - e. LEM Products Inc.
 - f. Marking Services, Inc.
 - g. Panduit Corp.

- h. Seton Identification Products.
- B. Snap-Around Labels for Raceways and Cables Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceways they identify, and that stay in place by gripping action.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Panduit Corp.
 - d. Seton Identification Products.
- C. Self-Adhesive Labels:
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. A'n D Cable Products.
 - b. Brady Corporation.
 - c. Brother International Corporation.
 - d. Emedco.
 - e. Grafoplast Wire Markers.
 - f. Ideal Industries, Inc.
 - g. LEM Products Inc.
 - h. Marking Services, Inc.
 - i. Panduit Corp.
 - j. Seton Identification Products.
 - 2. Preprinted, 3-mil-thick, polyester or vinyl flexible label with acrylic pressure-sensitive adhesive.
 - a. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized to fit the cable or raceway diameter, such that the clear shield overlaps the entire printed legend.
 - 3. Polyester or Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
 - a. Nominal Size: 3.5-by-5-inch.
 - 4. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 5. Marker for Tags: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

2.4 BANDS AND TUBES:

- A. Snap-Around, Color-Coding Bands for Raceways and Cables: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceways or cables they identify, and that stay in place by gripping action.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Marking Services, Inc.
 - c. Panduit Corp.
- B. Heat-Shrink Preprinted Tubes: Flame-retardant polyolefin tubes with machine-printed identification labels, sized to suit diameters of and shrunk to fit firmly around cables they identify. Full shrink recovery occurs at a maximum of 200 deg F. Comply with UL 224.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Panduit Corp.

2.5 TAPES AND STENCILS:

- A. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Carlton Industries, LP.
 - b. Champion America.
 - c. Ideal Industries, Inc.
 - d. Marking Services, Inc.
 - e. Panduit Corp.
- B. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; not less than 3 mils thick by 1 to 2 inches wide; compounded for outdoor use.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.

- c. Emedco.
 - d. Marking Services, Inc.
- C. Tape and Stencil for Raceways Carrying Circuits 600 V or Less: 4-inch-wide black stripes on 10-inch centers placed diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.
 - 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. LEM Products Inc.
 - b. Marking Services, Inc.
 - c. Seton Identification Products.
- D. Floor Marking Tape: 2-inch-wide, 5-mil pressure-sensitive vinyl tape, with yellow and black stripes and clear vinyl overlay.
 - 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. Carlton Industries, LP.
 - b. Seton Identification Products.
- E. Underground-Line Warning Tape
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Ideal Industries, Inc.
 - c. LEM Products Inc.
 - d. Marking Services, Inc.
 - e. Reef Industries, Inc.
 - f. Seton Identification Products.
 - 2. Tape:
 - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - c. 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.
 - 3. Color and Printing:

- a. Comply with ANSI Z535.1, ANSI Z535.2, ANSI Z535.3, ANSI Z535.4, and ANSI Z535.5.
 - b. Inscriptions for Red-Colored Tapes: "ELECTRIC LINE, HIGH VOLTAGE".
 - c. Inscriptions for Orange-Colored Tapes: "TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE".
4. Tag:
- a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core; bright colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - b. Width: 3 inches.
 - c. Overall Thickness: 5 mils.
 - d. Foil Core Thickness: 0.35 mil.
 - e. Weight: 28 lb/1000 sq. ft..
 - f. Tensile according to ASTM D 882: 70 lbf and 4600 psi.
- F. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.

2.6 Tags

- A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
- a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.
 - e. Seton Identification Products.
- B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
- a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Grafoplast Wire Markers.
 - e. LEM Products Inc.

- f. Marking Services, Inc.
- g. Panduit Corp.
- h. Seton Identification Products.

C. Write-On Tags:

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. Carlton Industries, LP.
 - b. LEM Products Inc.
 - c. Seton Identification Products.
2. Polyester Tags: 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to raceway, conductor, or cable.
3. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.7 Signs

A. Baked-Enamel Signs:

1. Preprinted aluminum signs punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 7 by 10 inches.
4. 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. Carlton Industries, LP.
 - b. Champion America.
 - c. Emedco.
 - d. Marking Services, Inc.

B. Metal-Backed Butyrate Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs, with 0.0396-inch galvanized-steel backing and with colors, legend, and size required for application.
2. 1/4-inch grommets in corners for mounting.
3. Nominal Size: 10 by 14 inches.
4. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Champion America.

- c. Emedco.
- d. Marking Services, Inc.

C. Laminated Acrylic or Melamine Plastic Signs:

- 1. Engraved legend.
- 2. Thickness:
 - a. For signs up to 20 sq. inches, minimum 1/16-inch-
 - b. For signs larger than 20 sq. inches, 1/8 inch thick.
 - c. Engraved legend with black letters on white face.
 - d. Punched or drilled for mechanical fasteners.
 - e. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- 3. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Brady Corporation.
 - b. Carlton Industries, LP.
 - c. Emedco.
 - d. Marking Services, Inc.

2.8 CABLE TIES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. Ideal Industries, Inc.
 - 2. Marking Services, Inc.
 - 3. Panduit Corp.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black, except where used for color-coding.
- C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg F.
 - 4. Color: Black.

- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, self-locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F.
 - 5. Color: Black.

2.9 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. 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.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- G. Attach plastic raceway and cable labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.

- H. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. Outdoors: UV-stabilized nylon.
 - 2. In Spaces Handling Environmental Air: Plenum rated.
- I. Painted Identification: Comply with requirements in painting Sections for surface preparation and paint application.
- J. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- K. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- L. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.

3.3 IDENTIFICATION SCHEDULE

- A. Accessible Raceways Armored and Metal-Clad Cables, More Than 600 V: Snap-around labels. Install labels at 10-foot maximum intervals.
- B. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits, More Than 30 A and 120 V to Ground: Identify with self-adhesive vinyl label. Install labels at 30-foot maximum intervals.
- C. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels containing the wiring system legend and system voltage. System legends shall be as follows:
 - 1. "STANDBY POWER."
 - 2. "POWER."
 - 3. "UPS."
- D. 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.
- c. Colors for 480/277-V Circuits:
- 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.
- d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- E. Power-Circuit Conductor Identification, More Than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic preprinted tags colored and marked to indicate phase, and a separate tag with the circuit designation.
- F. Install instructional sign, including the color code for grounded and ungrounded conductors using adhesive-film-type labels.
- G. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, use self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.
- H. Control-Circuit Conductor Termination Identification: For identification at terminations, provide self-adhesive, self-laminating polyester labels with the conductor designation.
- I. Conductors To Be Extended in the Future: Attach marker tape to conductors and list source.
- J. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker-tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- K. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical-fiber cable.
1. Limit use of underground-line warning tape to direct-buried cables.
 2. Install underground-line warning tape for direct-buried cables and cables in raceways.

- L. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall comply with NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
- M. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Metal-backed, butyrate warning signs.
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment, including, but not limited to, the following:
 - a. Power-transfer switches.
 - b. Controls with external control power connections.
- N. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
- O. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum 3/8-inch-high letters for emergency instructions at equipment used for power transfer.
- P. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual. Apply labels 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 unless equipment is provided with its own identification.
 - 1. Labeling Instructions:
 - a. Indoor Equipment: Engraved, laminated acrylic or melamine plastic label, punched or drilled for mechanical fasteners. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
 - b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
 - c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - d. Unless labels are provided with self-adhesive means of attachment, fasten them with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
 - 2. Equipment To Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be in the form of a engraved, laminated acrylic or melamine label.

- 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. Power-generating units.
- q. Monitoring and control equipment.
- r. UPS equipment.

END OF SECTION

SECTION 26 09 23
LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Time switches.
2. Photoelectric switches.
3. Standalone daylight-harvesting switching and dimming controls.
4. Indoor occupancy and vacancy sensors.
5. Switchbox-mounted occupancy sensors.
6. Digital timer light switches.
7. High-bay occupancy sensors.
8. Extreme temperature occupancy sensors.
9. Outdoor motion sensors.
10. Lighting contactors.
11. Emergency shunt relays.

B. Related Requirements:

1. Section 262726 "Wiring Devices" for wall-box dimmers, non-networkable wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:
 - a. Occupancy sensors.
 - b. Vacancy sensors.
2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's warranties.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.
- B. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On USB media. Provide names, versions, and website addresses for locations of installed software.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.

1.6 WARRANTY

- A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Faulty operation of lighting control software.
 - b. Faulty operation of lighting control devices.
 - 2. Warranty Period: Two year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 INDOOR OCCUPANCY AND VACANCY SENSORS

- 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. Acuity Brands.
 - 2. Cooper Industries, Inc.
 - 3. Leviton Manufacturing Co., Inc.
- B. General Requirements for Sensors:
 - 1. Wall or Ceiling-mounted, solid-state indoor occupancy and vacancy sensors.
 - 2. Dual technology.
 - 3. Integrated power pack.

4. Hardwired connection to switch ; and BAS and lighting control system.
 5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 6. Operation:
 - a. Vacancy Sensor: Unless otherwise indicated, lights are manually turned on and sensor turns lights off when the room is unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 7. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A Sensor is powered from the power pack Wireless.
 8. Power: Line voltage.
 9. Power Pack: Dry contacts rated for 20-A LED 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.
 10. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 11. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 12. Bypass Switch: Override the "on" function in case of sensor failure.
 13. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc; turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Wall or 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- minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/s.
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on a 96-inch- high ceiling.
 4. Detection Coverage (Room, Wall Mounted): Detect occupancy anywhere within a 180-degree pattern centered on the sensor over an area of 2000 square feet when mounted 48 inches above finished floor.

2.2 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

- 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. Acuity Brands.
 2. Cooper Industries, Inc.
 3. Leviton Manufacturing Co., Inc.
- B. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-off switch, suitable for mounting in a single gang switchbox, with provisions for connection to BAS using hardwired connection.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F.
 4. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V, and 800-W incandescent.
- C. Wall-Switch Sensor Tag WS1:
1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 2100 sq. ft.
 2. Sensing Technology: Dual technology - PIR and ultrasonic.
 3. Switch Type: SP, manual "on," automatic "off" or SP, field-selectable automatic "on," or manual "on," automatic "off."
 4. Capable of controlling load in three-way application.
 5. Voltage: Match the circuit voltage.
 6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc. The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
 7. Concealed, field, "off" time-delay selector at up to 30 minutes.
 8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
 9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
 10. Color: as specified by architect.
 11. Faceplate: Color matched to switch.

2.3 LIGHTING CONTACTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. ASCO Power Technologies, LP; a business of Emerson Network Power.
 2. Eaton.
 3. General Electric Company.
 4. Square D.
- B. Description: Electrically operated and electrically held, combination-type lighting contactors with nonfused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less THD of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

2.4 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. Lighting Control and Design.
 2. WattStopper; a Legrand® Group brand.
- B. Description: NC, electrically held relay, arranged for wiring in parallel with manual or automatic switching contacts; complying with UL 924.
 1. Coil Rating: as specified on drawings.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "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 Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.
- B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SENSOR INSTALLATION

- A. Comply with NECA 1.
- B. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression systems, and partition assemblies.
- C. 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.

3.3 CONTACTOR INSTALLATION

- A. Comply with NECA 1.
- B. 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.

3.4 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 3/4 inch.
- C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.5 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.6 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Operational Test: After installing time switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Lighting control devices will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.
 - 3. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

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. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.16 "Addressable-Luminaire Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."

- B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Instrumentation.
 - 5. Control power.
 - 6. Accessory components and features.
 - 7. Identification.

1.3 ACTION SUBMITTALS

- A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
 - 1. 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 of switchboards and overcurrent protective devices.
 - 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 - 6. Detail utility company's metering provisions with indication of approval by utility company.
 - 7. Include evidence of NRTL listing for series rating of installed devices.

8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 9. Include diagram and details of proposed mimic bus.
 10. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Routine maintenance requirements for switchboards and all installed components.
 - b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - c. 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.

1.6 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type but no fewer than two of each size and type.
 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 3. 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.

4. Fuses for Fused Power-Circuit Devices: Equal to 10 percent of quantity installed for each size and type but no fewer than three of each size and type.
5. Indicating Lights: Equal to 10 percent of quantity installed for each size and type but no less than one of each size and type.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.9 FIELD 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 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. 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. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Three years from date of Substantial Completion.
- B. Manufacturer's Warranty: Manufacturer's agrees to repair or replace surge protection 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 SWITCHBOARDS

- 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. Eaton.
 2. General Electric Company.
 3. Siemens Power Transmission & Distribution, Inc.
 4. Square D; by Schneider Electric.
- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

- 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 NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.
- H. Front-Connected, Front-Accessible Switchboards:
 - 1. Main Devices: Fixed, individually mounted.
 - 2. Branch Devices: Panel mounted.
 - 3. Sections front and rear aligned.
- I. Nominal System Voltage: 208Y/120 V.
- J. Main-Bus Continuous: See drawings for ampere rating.
- K. Indoor Enclosures: Steel, NEMA 250, Type 1.
- L. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- M. Barriers: Between adjacent switchboard sections.
- N. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- O. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.
- P. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable 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.
- Q. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks.
- R. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

- S. Hinged Front Panels: Allow access to switch, metering, accessory, and blank compartments.
- T. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
 - 2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, silver-plated.
 - 3. Copper feeder switch line connections.
 - 4. Ground Bus: 1/4-by-2-inch- (6-by-50-mm-) hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors.
 - 5. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 - 6. Disconnect Links:
 - a. Isolate neutral bus from incoming neutral conductors.
 - b. Bond neutral bus to equipment-ground bus for switchboards utilized as service equipment or separately derived systems.
 - 7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - 8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- U. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of switch compartment.

2.2 SURGE PROTECTION 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. Advanced Protection Technologies Inc. (APT).
 - 2. Eaton.
 - 3. General Electric Company.
 - 4. Siemens Power Transmission & Distribution, Inc.
 - 5. Square D; by Schneider Electric.
- B. SPDs: Comply with UL 1449, Type 2.
- C. Features and Accessories:
 - 1. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
 - 2. Indicator light display for protection status.
 - 3. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on

- failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
4. Surge counter.
- D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 300 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.
- E. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:
1. Line to Neutral: 700 V for 208Y/120 V.
 2. Line to Ground: 1200 V for 208Y/120 V.
 3. Line to Line: 1000 V for 208Y/120 V.
- F. SCCR: Equal or exceed 100 kA.
- G. Nominal Rating: 20 kA.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Main Service Switch - Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
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. Boltswitch, Inc.
 - b. Eaton.
 - c. Siemens Industry, Inc.
 - d. Square D.
 2. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
 3. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
 - a. Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
 4. Auxiliary Switches: Factory installed, SPDT, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
 5. Service-Rated Switches: Labeled for use as service equipment.
 6. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.

- B. Branch Devices - 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. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 4. 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. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position
- C. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- D. Fuses are specified in Section 262813 "Fuses."

2.4 INSTRUMENTATION

- A. Instrument Transformers: NEMA EI 21.1, and the following:
1. Potential Transformers: NEMA EI 21.1; 120 V, 60 Hz, single secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 2. Current Transformers: NEMA EI 21.1; 5 A, 60 Hz, secondary; wound type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.

- B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
 - a. Phase Currents, Each Phase: Plus, or minus 0.5 percent.
 - b. Phase-to-Phase Voltages, Three Phase: Plus, or minus 0.5 percent.
 - c. Phase-to-Neutral Voltages, Three Phase: Plus, or minus 0.5 percent.
 - d. Megawatts: Plus, or minus 1 percent.
 - e. Megavars: Plus, or minus 1 percent.
 - f. Power Factor: Plus, or minus 1 percent.
 - g. Frequency: Plus, or minus 0.1 percent.
 - h. Accumulated Energy, Megawatt Hours: Plus, or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
 - i. Megawatt Demand: Plus, or minus 1 percent; demand interval programmable from five to 60 minutes.
 2. Mounting: Display and control unit flush or semi flush mounted in instrument compartment door.

2.5 CONTROL POWER

- A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

2.6 IDENTIFICATION

- A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
 2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
 3. Protect from moisture, dust, dirt, and debris during storage and installation.
 4. Install temporary heating during storage per manufacturer's instructions.
- 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 or that affect the performance of the equipment.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install switchboards and accessories according to NEMA PB 2.1.
- 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 conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches (50-mm) above concrete base after switchboard is anchored in place.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
 - 3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to switchboards.
 - 6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.
- D. Install filler plates in unused spaces of panel-mounted sections.
- E. Install overcurrent protective devices, surge protection devices, and instrumentation.
- F. Comply with NECA 1.

3.3 CONNECTIONS

- A. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.
- B. Support and secure conductors within the switchboard according to NFPA 70.
- C. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting, and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
 - 1. Acceptance Testing:
 - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
 - b. Test continuity of each circuit.
 - 2. Test ground-fault protection of equipment for service equipment per NFPA 70.
 - 3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 5. Perform the following infrared scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 6. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

- B. Switchboard will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

3.7 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. ATS: Acceptance testing specification.
- B. GFCI: Ground-fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. HID: High-intensity discharge.
- E. MCCB: Molded-case circuit breaker.
- F. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of panelboard.
 - 1. Include materials, switching and overcurrent protective devices, accessories, and components indicated.
 - 2. 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.

2. Show tabulations of installed devices with nameplates, conductor termination sizes, equipment features, and ratings.
3. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
4. Detail bus configuration, current, and voltage ratings.
5. Short-circuit current rating of panelboards and overcurrent protective devices.
6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include wiring diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.7 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. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers Including GFCI and GFEP Types: Two spares for each panelboard.

1.8 QUALITY ASSURANCE

- A. Manufacturer Qualifications: ISO 9001 or 9002 certified.

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 FIELD CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 23 deg F to plus 104 deg F.
 - b. Altitude: Not exceeding 6600 feet.

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.11 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 18 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

- A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- 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 1.
- D. Comply with NFPA 70.

- E. Enclosures: Flush and Surface-mounted, dead-front cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 4.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 2. Height: 84 inches maximum.
 - 3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
 - 4. Finishes:
 - a. Panels and Trim: Steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel.
- F. Incoming Mains:
 - 1. Location: Convertible between top and bottom.
 - 2. Main Breaker: Main lug interiors up to 400 amperes shall be field convertible to main breaker.
- G. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 - 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 - 3. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 4. Full-Size Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
- H. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Terminations shall allow use of 75 deg C rated conductors without derating.
 - 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 - 4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 - 5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.

6. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
7. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
- I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
 1. Percentage of Future Space Capacity: 20 percent.
- J. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.
 1. Panelboards and overcurrent protective devices rated 240 V or less shall have short-circuit ratings as shown on Drawings, but not less than 10,000 A rms symmetrical.
 2. Panelboards and overcurrent protective devices rated above 240 V and less than 600 V shall have short-circuit ratings as shown on Drawings, but not less than 14,000 A rms symmetrical.

2.2 POWER PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company; GE Energy Management - Electrical Distribution.
 3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
 1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker or Lugs only.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers.

2.3 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

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

1. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company; GE Energy Management - Electrical Distribution.
 3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker or lugs only.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Door-in-door construction with concealed hinges; secured with multipoint latch with tumbler lock; keyed alike. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed.

2.4 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Sector; Eaton Corporation.
 2. General Electric Company; GE Energy Management - Electrical Distribution.
 3. Siemens Energy.
 4. Square D; by Schneider Electric.
- B. MCCB: Comply with UL 489, with interrupting capacity to meet available fault currents.
1. Thermal-Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 2. GFCI Circuit Breakers: Single- and double-pole configurations with Class A ground-fault protection (6-mA trip).
 3. GFEP Circuit Breakers: Class B ground-fault protection (30-mA trip).
 4. Subfeed Circuit Breakers: Vertically mounted.
 5. MCCB Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Breaker handle indicates tripped status.
 - c. UL listed for reverse connection without restrictive line or load ratings.
 - d. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
 - e. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and HID lighting circuits.

- f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
- h. Rating Plugs: Three-pole breakers with ampere ratings greater than 150 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
- i. Multipole units enclosed in a single housing with a single handle.
- j. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.5 IDENTIFICATION

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in metal frame with transparent protective cover.
 - 1. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.

2.6 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.
- C. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- D. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Comply with NECA 1.
- C. Install panelboards and accessories according to NEMA PB 1.1.
- D. Equipment Mounting:
 - 1. Attach panelboard to the vertical finished or structural surface behind the panelboard.
- E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.
- F. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- G. Mount panelboard cabinet plumb and rigid without distortion of box.
- H. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- I. Mounting panelboards with space behind is recommended for damp, wet, or dirty locations. The steel slotted supports in the following paragraph provide an even mounting surface and the recommended space behind to prevent moisture or dirt collection.
- J. Mount surface-mounted panelboards to steel slotted supports 1 1/4 inch in depth. Orient steel slotted supports vertically.
- K. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
 - 2. Tighten bolted connections and circuit breaker connections using calibrated torque wrench or torque screwdriver per manufacturer's written instructions.
- L. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.
- M. Install filler plates in unused spaces.

- N. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- O. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA ATS, Paragraph 7.6 Circuit Breakers. Perform optional tests. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each

panelboard. Remove front panels so joints and connections are accessible to portable scanner.

b. Instruments and Equipment:

- 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes. Prior to making circuit changes to achieve load balancing, inform Architect of effect on phase color coding.

1. Measure loads during period of normal facility operations.
2. Perform circuit changes to achieve load balancing outside normal facility operation schedule or at times directed by the Architect. Avoid disrupting services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After changing circuits to achieve load balancing, recheck loads during normal facility operations. Record load readings before and after changing circuits to achieve load balancing.
4. Tolerance: Maximum difference between phase loads, within a panelboard, shall not exceed 20 percent.

3.6 PROTECTION

A. Temporary Heating: Prior to energizing panelboards, apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION

SECTION 262713
ELECTRICITY METERING

PART 1 - GENERAL

1.1 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 work to accommodate utility company revenue meters.

1.3 ACTION SUBMITTALS

- A. Product Data:
 - 1. For each type of meter.
 - 2. For metering infrastructure components.
 - 3. For metering software.
- B. Shop Drawings: For electricity-metering equipment.
 - 1. Include elevation views of front panels of control and indicating devices and control stations.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Wire Termination Diagrams and Schedules: Include diagrams for power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features. Differentiate between manufacturer-installed and field-installed wiring.
 - 4. Include series-combination rating data for modular meter centers with main disconnect device.

1.4 FIELD 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. Owner shall be notified and issued written permission no fewer than seven days in advance of proposed interruption of electrical service.

1.5 COORDINATION

A. Electrical Service Connections:

1. Coordinate with utility companies and utility-furnished components.
 - a. Comply with requirements of utility providing electrical power services.
 - b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 916.

2.2 UTILITY METERING INFRASTRUCTURE

- A. Install metering accessories furnished by the utility company, complying with its requirements.
- B. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
- C. Meter Sockets:
 1. Comply with requirements of electrical-power utility company.
 2. Meter Sockets: Steady-state and short-circuit current ratings shall meet indicated circuit ratings.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.
- B. Install meters furnished by utility company. Install raceways and equipment according to utility company's written instructions. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Wiring Method:

1. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
2. Minimum conduit size shall be 1/2 inch (13 mm).

3.2 IDENTIFICATION

A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Series Combination Warning Label: Self-adhesive labels, with text as required by NFPA 70.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. USB charger devices.
 - 3. Twist-locking receptacles.
 - 4. Weather-resistant receptacles.
 - 5. Snap switches.
 - 6. Pendant cord-connector devices.
 - 7. Cord and plug sets.
 - 8. Floor service outlets and poke-through assemblies.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- C. 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.

- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

1.6 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

1.8 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. Floor Service-Outlet Assemblies: One for every 10, but no fewer than one.
 - 2. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no fewer than two.

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 Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - 2. Hubbell Incorporated; Wiring Device-Kellems.
 - 3. Leviton Manufacturing Co., Inc.
 - 4. 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 USB CHARGER DEVICES

- A. Tamper-Resistant, USB Charger Receptacles: 12 V dc, 2.0 A, USB Type A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, UL 1310, and FS W-C-596.
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 (Arrow Hart).
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 2. Description: Single-piece, rivetless, nickel-plated, all-brass grounding system. Nickel-plated, brass mounting strap.
 3. USB Receptacles: Dual, Type A.
 4. Line Voltage Receptacles: Dual, two pole, three wire, and self-grounding.

2.4 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration as indicated on drawings, and UL 498.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

2.5 PENDANT CORD-CONNECTOR DEVICES

- A. Description:
1. Matching, locking-type plug and receptacle body connector.
 2. NEMA WD 6 Configurations L5-20P and L5-20R, heavy-duty grade, and FS W-C-596.
 3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
 4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.7 DECORATOR-STYLE DEVICES

A. Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, and UL 498.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

B. GFCI, Feed-Through Type, Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943 Class 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. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).

C. GFCI, Weather-Resistant Convenience Receptacles: Square face, 125 V, 20 A; comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and UL 943 Class 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. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Pass & Seymour/Legrand (Pass & Seymour).

- D. Toggle Switches, Square Face, 120/277 V, 20 A: Comply with NEMA WD 1, UL 20, and FS W-S-896.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
- E. Lighted Toggle Switches, Square Face, 120 V, 20 A: Comply with NEMA WD 1 and UL 20.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - a. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
 - b. Hubbell Incorporated; Wiring Device-Kellems.
 - c. Leviton Manufacturing Co., Inc.
 - d. Pass & Seymour/Legrand (Pass & Seymour).
 - 2. Description: With neon-lighted handle, illuminated when switch is "off."
- F. All branch circuits rated at 15 amperes shall only have receptacles rated at 15 amperes connected to it.

2.8 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: Steel with white baked enamel, suitable for field painting.
 - 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.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.9 FLOOR SERVICE FITTINGS

- A. Type: Modular, flush-type, dual-service units suitable for wiring method used.
- B. Compartments: Barrier separates power from voice and data communication cabling.
- C. Service Plate: Rectangular, solid brass with satin finish.

- D. Power Receptacle: NEMA WD 6 Configuration 5-20R, gray finish, unless otherwise indicated.

2.10 POKE-THROUGH 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. Hubbell Incorporated; Wiring Device-Kellems.
2. Pass & Seymour/Legrand (Pass & Seymour).
3. Square D; by Schneider Electric.
4. Thomas & Betts Corporation, A Member of the ABB Group.
5. Wiremold / Legrand.

- B. Description:

1. Factory-fabricated and wired assembly of below-floor junction box with multichannel, through-floor raceway/firestop unit and detachable matching floor service-outlet assembly.
2. Comply with UL 514 scrub water exclusion requirements.
3. Service-Outlet Assembly: Pedestal type with services indicated.
4. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.
5. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
6. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.
7. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of four, four-pair cables.

2.11 FINISHES

- A. Device Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

- B. Wall Plate Color: For plastic covers, match device color.

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.
4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtail existing conductors is permitted, provided the outlet box is large enough.

D. Device Installation:

1. Replace 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 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. Dimmers:
 1. Install dimmers within terms of their listing.
 2. Verify that dimmers used for fan speed control are listed for that application.
 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
 - H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
 - I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.
- 3.2 GFCI RECEPTACLES
- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.
- 3.3 IDENTIFICATION
- A. Comply with Section 260553 "Identification for Electrical Systems."
- 3.4 FIELD QUALITY CONTROL
- A. Perform the following tests and inspections:
 1. Test Instruments: Use instruments that comply with UL 1436.
 2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display indicators of measurement.
 - B. Tests for Convenience Receptacles:
 1. Line Voltage: Acceptable range is 105 to 132 V.
 2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is unacceptable.
 3. Ground Impedance: Values of up to 2 ohms are acceptable.
 4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 5. Using the test plug, verify that the device and its outlet box are securely mounted.

6. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 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 the following:
 - a. Control circuits.
 - b. Switchboards.
 - c. Enclosed controllers.
 - d. Enclosed switches.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles. Include the following for each fuse type indicated:
 - 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 - 2. Coordination charts and tables and related data.
 - 3. Fuse sizes for elevator feeders and elevator disconnect switches.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017700 "Closeout Procedures," include the following:
 - 1. Ambient temperature adjustment information.
 - 2. Current-limitation curves for fuses with current-limiting characteristics.
 - 3. Coordination charts and tables and related data.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.6 FIELD CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper Bussmann; a division of Cooper Industries.
 - 2. Edison; a brand of Cooper Bussmann; a division of Cooper Industries.
 - 3. Littelfuse, Inc.
 - 4. Mersen USA.
- B. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, current-limiting, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
 - 1. Type RK-1: 600-V, zero- to 600-A rating, 200 kAIC, time delay.
 - 2. Type CC: 600-V, zero- to 30-A rating, 200 kAIC, fast acting.
 - 3. Type J: 600-V, zero- to 600-A rating, 200 kAIC.
 - 4. Type L: 600-V, 601- to 6000-A rating, 200 kAIC, time delay.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.

- E. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Service Entrance: Class L, time delay.
 - 2. Feeders: Class RK1, time delay.
 - 3. Motor Branch Circuits: Class RK1, time delay.
 - 4. Power Electronics Circuits: Class J, high speed.
 - 5. Other Branch Circuits: Class J, fast acting.
 - 6. Control Transformer Circuits: Class CC, time delay, control transformer duty.
 - 7. Provide open-fuse indicator fuses or fuse covers with open fuse indication.

3.3 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems" and indicating fuse replacement information inside of door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

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.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Fuse Pullers: Two for each size and type.

1.8 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

1.9 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg F.
2. Altitude: Not exceeding 6600 feet.

1.10 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 Sector; Eaton Corporation.
 2. General Electric Company.
 3. Siemens Industry, Inc.
 4. Square D; by Schneider Electric.
- 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. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 5. Lugs: Mechanical type, suitable for number, size, and conductor material.
 6. Service-Rated Switches: Labeled for use as service equipment.
 7. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Eaton Electrical Sector; Eaton Corporation.

2. General Electric Company.
 3. Siemens Industry, Inc.
 4. Square D; by 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. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 4. Lugs: Mechanical type, suitable for number, size, and conductor material.
 5. Accessory Control Power Voltage: Remote mounted and powered; 120-V ac.

2.3 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 4.
 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance 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. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.

- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 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. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test 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.
 - 3. Perform the following infrared scan tests and inspections and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION

SECTION 26 43 13

SURGE PROTECTION FOR LOW-VOLTAGE ELECTRICAL POWER CIRCUITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes field-mounted SPDs for low-voltage (120 to 600 V) power distribution and control equipment.

1.3 DEFINITIONS

- A. Inominal: Nominal discharge current.
- B. MCOV: Maximum continuous operating voltage.
- C. Mode(s), also Modes of Protection: The pair of electrical connections where the VPR applies.
- D. MOV: Metal-oxide varistor; an electronic component with a significant non-ohmic current-voltage characteristic.
- E. OCPD: Overcurrent protective device.
- F. SCCR: Short-circuit current rating.
- G. SPD: Surge protective device.
- H. VPR: Voltage protection rating.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 2. Copy of UL Category Code VZCA certification, as a minimum, listing the tested values for VPRs, Inominal ratings, MCOVs, type designations, OCPD requirements, model numbers, system voltages, and modes of protection.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.
- B. Sample Warranty: For manufacturer's special warranty.

1.6 CLOSEOUT SUBMITTALS

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

1.7 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to replace or replace SPDs 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 SPD REQUIREMENTS

- A. SPD with Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Comply with UL 1449.
- D. MCOV of the SPD shall be the nominal system voltage.

2.2 SERVICE ENTRANCE SUPPRESSOR

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
 - 1. ABB USA.
 - 2. Advanced Protection Technologies Inc. (APT).
 - 3. Alltec Corporation.
 - 4. Current Technology Inc.
 - 5. Eaton Electrical Sector; Eaton Corporation.
 - 6. General Electric Company.
 - 7. LEA International.
 - 8. Leviton Manufacturing Co., Inc.
 - 9. Liebert; a brand of Emerson Electric Co.
 - 10. Schneider Electric USA, Inc.
 - 11. Siemens Industry, Inc.

12. Square D; by Schneider Electric.

B. SPDs: Comply with UL 1449, Type 2.

1. SPDs with the following features and accessories:

- a. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
- b. Indicator light display for protection status.
- c. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- d. Surge counter.

C. Comply with UL 1283.

D. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 320 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

E. Protection modes and UL 1449 VPR for grounded wye circuits with 480Y/277 V or 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 1200 V for 480Y/277 V.
2. Line to Ground: 1200 V for 480Y/277 V.
3. Line to Line: 2000 V for 480Y/277 V.
4. Line to Neutral: 700 V for 208Y/120 V.
5. Line to Ground: 1200 V for 208Y/120 V.
6. Line to Line: 1000 V for 208Y/120 V.

F. SCCR: Equal or exceed 100 kA.

G. Inominal Rating: 20 kA.

2.3 PANEL SUPPRESSORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:

1. ABB USA.
2. Advanced Protection Technologies Inc. (APT).
3. Alltec Corporation.
4. Atlantic Scientific.
5. Current Technology Inc.
6. Eaton Electrical Sector; Eaton Corporation.
7. General Electric Company.

8. LEA International.
9. Leviton Manufacturing Co., Inc.
10. Liebert; a brand of Emerson Electric Co.
11. Northern Technologies, Inc.

B. SPDs: Comply with UL 1449, Type 2.

1. Include LED indicator lights for power and protection status.
2. Internal thermal protection that disconnects the SPD before damaging internal suppressor components.
3. Include Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

C. Peak Surge Current Rating: The minimum single-pulse surge current withstand rating per phase shall not be less than 100 kA. The peak surge current rating shall be the arithmetic sum of the ratings of the individual MOVs in a given mode.

D. Protection modes and UL 1449 VPR for grounded wye circuits with 208Y/120 V, three-phase, four-wire circuits shall not exceed the following:

1. Line to Neutral: 700 V for 208Y/120 V.
2. Line to Ground: 700 V for 208Y/120 V.
3. Neutral to Ground: 700 V for 208Y/120 V.
4. Line to Line: 1200 V for 208Y/120 V

E. SCCR: Equal or exceed 100 kA.

F. Inominal Rating: 20 kA.

2.4 ENCLOSURES

- A. Indoor Enclosures: NEMA 250, Type 1.
- B. Outdoor Enclosures: NEMA 250, Type 3R.

2.5 CONDUCTORS AND CABLES

- A. Power Wiring: Same size as SPD leads, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Class 2 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1.
- B. Install an OCPD or disconnect as required to comply with the UL listing of the SPD.
- C. Install SPDs with conductors between suppressor and points of attachment as short and straight as possible, and adjust circuit-breaker positions to achieve shortest and straightest leads. Do not splice and extend SPD leads unless specifically permitted by manufacturer. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
- D. Use crimped connectors and splices only. Wire nuts are unacceptable.
- E. Wiring:
 - 1. Power Wiring: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. Controls: Comply with wiring methods in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Compare equipment nameplate data for compliance with Drawings and Specifications.
 - 2. Inspect anchorage, alignment, grounding, and clearances.
 - 3. Verify that electrical wiring installation complies with manufacturer's written installation requirements.
- B. An SPD will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Complete startup checks according to manufacturer's written instructions.
- B. Do not perform insulation-resistance tests of the distribution wiring equipment with SPDs installed. Disconnect SPDs before conducting insulation-resistance tests, and reconnect them immediately after the testing is over.
- C. Energize SPDs after power system has been energized, stabilized and tested.

3.4 DEMONSTRATION

- A. Train Owner's maintenance personnel to operate and maintain SPDs.

END OF SECTION

SECTION 26 51 19
LED 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. Lighting fixture supports.
- B. Related Requirements:
 - 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.

2. Include data on features, accessories, and finishes.
3. Include physical description and dimensions of luminaires.
4. Include emergency lighting units, including batteries and chargers.
5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
6. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing and Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the lighting fixture as applied in this Project.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

- B. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

- A. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- B. Product Certificates: For each type of luminaire.
- C. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.
- D. Sample 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. Lamps: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
 2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
 3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

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. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 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 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. Recessed Fixtures: Comply with NEMA LE 4.
- D. Bulb shape complying with ANSI C79.1.
- E. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- F. Rated lamp life of 35,000 hours.
- G. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- H. Internal driver.
- I. Nominal Operating Voltage: As indicated on Plans.

1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

J. Housings:

1. Extruded-aluminum housing and heat sink.
2. powder-coat finish.

2.2 DOWNLIGHT

- A. See Plans for manufacturers.
- B. Minimum 1,000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Universal mounting bracket.
- D. Integral junction box with conduit fittings.

2.3 LINEAR INDUSTRIAL

- A. See Plans for manufacturers.
- B. Minimum 5,000 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Housing and heat sink rated to the following:
 1. NEMA 4X.
 2. IP 54.
 3. IP 66.
 4. Marine and wet locations.
 5. CSA C22.2 No 137.

2.4 RECESSED LINEAR

- A. See Plans for manufacturers.
- B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.
- C. Integral junction box with conduit fittings.

2.5 STRIP LIGHT

- A. See Plans for manufacturers.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.6 SURFACE MOUNT, LINEAR

- A. See Plans for manufacturers.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.7 SURFACE MOUNT, NONLINEAR

- A. See Plans for manufacturers.
- B. Minimum 750 lumens. Minimum allowable efficacy of 80 lumens per watt.
- C. Integral junction box with conduit fittings.

2.8 SUSPENDED, LINEAR

- A. See Plans for manufacturers.
- B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.

2.9 SUSPENDED, NONLINEAR

- A. See Plans for manufacturers.
- B. Minimum 2,000 lumens. Minimum allowable efficacy of 85 lumens per watt.
- C. Integral junction box with conduit fittings.

2.10 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. Diffusers and Globes:
 - 1. prismatic acrylic
 - 2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

1. Extruded-aluminum housing and heat sink.
2. powder-coat finish.

E. 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.

2.11 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.

2.12 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 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.
- D. Rod Hangers: 3/16-inch 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 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaire Support:
 - 1. Secured to outlet box.
 - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
 - 3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
 - 2. Do not attach luminaires directly to gypsum board.
- G. Ceiling-Mounted Luminaire Support:
 - 1. Ceiling mount with two 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
 - 2. Ceiling mount with pendant mount with 5/32-inch-diameter aircraft cable supports adjustable to 120 inches in length.
 - 3. Ceiling mount with hook mount.
- H. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

I. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

- B. Luminaire will be considered defective if it does not pass operation tests and inspections.

- C. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to

suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

SECTION 26 52 19
EMERGENCY AND EXIT 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. Emergency lighting units.
 - 2. Exit signs.
 - 3. Luminaire supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Emergency Lighting Unit: A lighting unit with internal or external emergency battery powered supply and the means for controlling and charging the battery and unit operation.
- D. Fixture: See "Luminaire" Paragraph.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
 - 1. Include data on features, accessories, and finishes.
 - 2. Include physical description of the unit and dimensions.
 - 3. Battery and charger for light units.
 - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.

5. Include photometric data and adjustment factors based on laboratory tests, complying with IES LM-45, for each luminaire type.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Shop Drawings: For nonstandard or custom luminaires.
 1. Include plans, elevations, sections, and mounting and attachment details.
 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. Product Schedule:
 1. For emergency lighting units. Use same designations indicated on Drawings.
 2. For exit signs. Use same designations indicated on Drawings.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For each type of luminaire.
- B. Product Test Reports: For each luminaire for tests performed by manufacturer and witnessed by a qualified testing agency.
- C. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, 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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
 2. Luminaire-mounted, emergency battery pack: One for every 20 emergency lighting units. Furnish at least one of each type.
 3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.

4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Two year(s) from date of Substantial Completion.
- B. Special Warranty for Emergency Lighting Batteries: Manufacturer's standard form in which manufacturer of battery-powered emergency lighting unit agrees to repair or replace components of rechargeable batteries that fail in materials or workmanship within specified warranty period.
 1. Warranty Period for Emergency Power Unit Batteries: 5 years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.
 2. Warranty Period for Emergency Fluorescent Ballast and Self-Powered Exit Sign Batteries: Seven years from date of Substantial Completion. Full warranty shall apply for the entire warranty period.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

- 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: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. Comply with NEMA LE 4 for recessed luminaires.

- E. Comply with UL 1598 for fluorescent luminaires.
- F. Lamp Base: Comply with ANSI C81.61 or IEC 60061-1.
- G. Bulb Shape: Complying with ANSI C79.1.
- H. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.
 - 1. Emergency Connection: Operate one lamp(s) continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
 - 2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Less than 0 deg F or exceeding 104 deg F, with an average value exceeding 95 deg F over a 24-hour period.
 - b. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F.
 - c. Humidity: More than 95 percent (condensing).
 - d. Altitude: Exceeding 3300 feet.
 - 4. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
 - 5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 - 6. Battery: Sealed, maintenance-free, nickel-cadmium type.
 - 7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
 - 8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.

2.2 EMERGENCY LIGHTING

- A. General Requirements for Emergency Lighting Units: Self-contained units.
- B. Emergency Luminaires:

1. See Plans for manufacturers.
2. Emergency Luminaires: as indicated on Interior Lighting Fixture Schedule, with the following additional features:
 - a. Operating at nominal voltage of 120 V ac or 277 V ac.
 - b. Internal emergency power unit.
 - c. Rated for installation in damp locations, and for sealed and gasketed luminaires in wet locations.

C. Emergency Lighting Unit:

1. See Plans for manufacturers.
2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. Two LED lamp heads.
7. Internal emergency power unit.

D. Remote Emergency Lighting Units:

1. See Plans for manufacturers.
2. Emergency Lighting Unit: as indicated on Interior Lighting Fixture Schedule.
3. Operating at nominal voltage of 120 V ac or 277 V ac.
4. Wall with universal junction box adaptor.
5. UV stable thermoplastic housing, rated for damp locations.
6. LED lamp heads.
7. External emergency power unit.

2.3 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. See Plans for manufacturers.
2. Operating at nominal voltage of 120 V ac or 277 V ac.
3. Lamps for AC Operation: Fluorescent, two for each luminaire; 20,000 hours of rated lamp life.
4. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
5. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.
6. Master/Remote Sign Configurations:
 - a. Master Unit: Comply with requirements above for self-powered exit signs, and provide additional capacity in LED power supply and battery for power connection to remote unit.

- b. Remote Unit: Comply with requirements above for self-powered exit signs, except omit power supply, battery, and test features. Arrange to receive full power requirements from master unit. Connect for testing concurrently with master unit as a unified system.

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:

- 1. Smooth operating, free of light leakage under operating conditions.
- 2. Designed to permit relamping without use of tools.
- 3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

- 1. Prismatic acrylic.
- 2. Acrylic: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Housings:

- 1. Extruded aluminum housing and heat sink.
- 2. powder coat finish.

E. Conduit: Electrical metallic tubing or Flexible metallic conduit, minimum 3/4 inch in diameter.

2.5 METAL FINISHES

- A. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.
- B. Support Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire and emergency power unit weight.
 - 2. Able to maintain luminaire position when testing emergency power unit.
 - 3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
 - 2. Do not attach luminaires directly to gypsum board.
- F. Suspended Luminaire Support:
 - 1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
 - 2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
 - 3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and wire support for suspension for each unit length of luminaire chassis, including one at each end.

4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

G. Ceiling Grid Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

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 the following tests and inspections:
 1. 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.

3.5 STARTUP SERVICE

- A. Perform startup service:
 1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
 2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

3.6 ADJUSTING

- A. Adjustments: Within 12 months of date of Substantial Completion, provide on-site visit to do the following:
 1. Inspect all luminaires. Replace lamps, emergency power units, batteries, signs, or luminaires that are defective.

- a. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
2. Conduct short-duration tests on all emergency lighting.

END OF SECTION

SECTION 26 56 19
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 solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.
- B. Related Requirements:
 - 1. Section 260923 "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of luminaire.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.

3. Include physical description and dimensions of luminaire.
4. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
5. Photometric data and adjustment factors based on laboratory tests, complying with IES Lighting Measurements Testing and Calculation Guides, of each luminaire type. The adjustment factors shall be for lamps and accessories identical to those indicated for the luminaire as applied in this Project.
 - a. Manufacturer's Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
6. Wiring diagrams for power, control, and signal wiring.
7. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.

B. LEED Submittals:

1. Product Data for Credit MR 4: For products having recycled content, documentation indicating percentages by weight of postconsumer and pre-consumer recycled content. Include statement indicating cost for each product having recycled content.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

D. Delegated-Design Submittal: For luminaire supports.

1. Include design calculations for luminaire supports.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of the following:

1. Luminaire.

B. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Source quality-control reports.

D. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires to include in operation and maintenance manuals.

1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.

1.7 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: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
 - 2. Glass, Acrylic, and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 3. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
 - 4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturers' laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.
- D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.10 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Mark locations of exterior luminaires for approval by Architect prior to the start of luminaire installation.

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.
 - 1. Failures include, but are not limited to, the following:

- a. Structural failures, including luminaire support components.
- b. Faulty operation of luminaires and accessories.
- c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

2.2 LUMINAIRE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. UL Compliance: Comply with UL 1598 and listed for wet location.
- D. Lamp base complying with ANSI C81.61 or IEC 60061-1.
- E. Bulb shape complying with ANSI C79.1.
- F. CRI of minimum 70. CCT of 4000 K.
- G. L70 lamp life of 50,000 hours.
- H. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- I. Internal driver.
- J. Nominal Operating Voltage: 277 V ac.
- K. Lamp Rating: Lamp marked for outdoor use and in enclosed locations.
- L. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.3 LUMINAIRE TYPES

- A. Area and Site:
 - 1. See Plans for manufacturers.
 - 2. Luminaire Shape: Square.

3. Mounting: Building.
4. Luminaire-Mounting Height: As indicated on architectural plans.
5. Distribution: Type IV.
6. Diffusers and Globes: Prismatic acrylic.
7. Housings:
 - a. Extruded-aluminum housing and heat sink.
 - b. powder-coat finish.

2.4 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 2. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 1. White Surfaces: 85 percent.
 2. Specular Surfaces: 83 percent.
 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:
 1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
 1. Label shall include the following lamp characteristics:

- a. "USE ONLY" and include specific lamp type.
- b. Lamp diameter, shape, size, wattage and coating.
- c. CCT and CRI for all luminaires.

2.5 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- C. Factory-Applied Finish for 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 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 - 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 - 4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
 - a. Color: As indicated on plans.

2.6 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is substantially complete, clean luminaires used for temporary lighting and install new lamps.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Install lamps in each luminaire.
- C. Fasten luminaire to structural support.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Support luminaires without causing deflection of finished surface.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
- F. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- G. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Drawings.
- H. Coordinate layout and installation of luminaires with other construction.
- I. Adjust luminaires that require field adjustment or aiming.
- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.4 BOLLARD LUMINAIRE INSTALLATION:

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.5 CORROSION PREVENTION

- A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
- B. Steel Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections:
 - 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- C. Illumination Tests:
 - 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 - 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.

- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.8 DEMONSTRATION

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

3.9 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

SECTION 27 05 28

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 SUSTAINABLE DESIGN OBJECTIVES

- A. The City requires the contractor to implement practices and procedures to meet the project's environmental performance goals, which include:
 - 1. Minimize the environmental impacts of the construction and operation of the project during the construction phase. The project shall implement the following procedures singly or in combination:
 - a. Select products that minimize consumption of non-renewable resources, consume reduced amounts of energy, minimize environmental pollution, and to utilize recycled and/or recyclable materials.
 - b. Reduce sources of potential Indoor Air Quality pollutants by controlled selection of materials and processes used in project construction. (015721)
 - c. Minimize waste produced by construction through efficient construction practices and landfill diversion, as detailed in the Construction Waste Management Plan. (017419)
 - 2. Products and processes that achieve the above objectives have been selected and included in the Construction Documents.

1.3 SUMMARY

- A. Section Includes:
 - 1. Metal conduits and fittings.
 - 2. Metal wireways and auxiliary gutters.
 - 3. Boxes, enclosures, and cabinets.
- B. Related Requirements:
 - 1. Section 260533 "Raceways and Boxes for Electrical Systems" for conduits, wireways, surface raceways, boxes, enclosures, cabinets, handholes, and faceplate adapters serving electrical systems.

1.4 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.5 ACTION SUBMITTALS

- A. Product Data: For surface pathways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For solvent cements and adhesive primers, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- C. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For licensed professional engineer.
- B. Source quality-control reports.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Comply with the requirements of the Construction Indoor Air Quality Management Plan and the Construction Waste Management Plan.

1.8 PROJECT CONDITIONS

- A. Waste Management: Comply with the requirements of the Construction Waste Management Plan.

PART 2 - PRODUCTS

2.1 PRODUCT REQUIREMENTS FOR SUSTAINABLE DESIGN- GENERAL

- A. All field applied paints, coatings, sealants, sealer, adhesives in this section shall meet the requirements of VOC limits in 016116- Indoor Finishes Performance Requirements.
- B. All Products in this Section shall be free of Materials of Concern as noted in 015721- Indoor Air Quality Control (where achievable).

2.2 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 or approved equal:
 - 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 qualified testing agency, and marked for intended location and application.
 - 2. Comply with TIA-569-B.
- 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 rigid steel conduit.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch, 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 886 and NFPA 70.
2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew.
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, with overlapping sleeves protecting threaded joints.

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 or approved equal:
1. Cooper B-Line, Inc.
 2. Hoffman.
 3. Mono-Systems, Inc.
 4. Square D.
- B. Description: Sheet metal, complying with UL 870 and 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. Comply with TIA-569-B.
- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.4 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 or approved equal:
1. Adalet.

2. Cooper Technologies Company; Cooper Crouse-Hinds.
 3. EGS/Appleton Electric.
 4. Hoffman.
 5. Mono-Systems, Inc.
 6. O-Z/Gedney.
 7. RACO; Hubbell.
 8. Robroy Industries.
 9. Spring City Electrical Manufacturing Company.
 10. Thomas & Betts Corporation.
 11. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets:
1. Comply with TIA-569-B.
 2. 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. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- F. Metal Floor Boxes:
1. Material: Cast metal.
 2. Type: Fully adjustable.
 3. Shape: Rectangular.
 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 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, galvanized, cast iron with gasketed cover.
- I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.
- J. Gangable boxes are prohibited.
- K. Nonmetallic Outlet and Device Boxes: Comply with NEMA OS 2 and UL 514C.
- 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.

M. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.
6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

PART 3 - EXECUTION

3.1 PATHWAY APPLICATION

- A. Indoors: Apply pathway products as specified below unless otherwise indicated:
1. Exposed, Not Subject to Physical Damage: RGS.
 2. Exposed, Not Subject to Severe Physical Damage: RGS.
 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 4. Boxes and Enclosures: NEMA 250 Type 1.
- B. Minimum Pathway Size: 3/4-inch trade size. Minimum size for optical-fiber cables is 1 inch.
- C. 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 setscrew, steel fittings. Comply with NEMA FB 2.10.
- D. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

3.2 INSTALLATION

- A. Comply with NECA 1, NECA 101, and TIA-569-B for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum pathways. Comply with NFPA 70 limitations for types of pathways allowed in specific occupancies and number of floors.
- B. Keep pathways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal pathway runs above water and steam piping.

- C. Complete pathway 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 two 90-degree bends in any pathway run. Support within 12 inches of changes in direction. Utilize long radius ells for all optical-fiber cables.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within 12 inches of enclosures to which attached.
- I. 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.
- J. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of pathway and fittings before making up joints. Follow compound manufacturer's written instructions.
- K. Coat field-cut threads on PVC-coated pathway with a corrosion-preventing conductive compound prior to assembly.
- L. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install insulated bushings on conduits terminated with locknuts.
- M. Install pathways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- N. 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.
- O. Cut conduit perpendicular to the length. For conduits of 2-inch trade size and larger, use roll cutter or a guide to ensure cut is straight and perpendicular to the length.
- P. Install pull wires in empty pathways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground pathways designated as spare above grade alongside pathways in use.
- Q. Pathways for Optical-Fiber and Communications Cable: Install pathways, metal and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch Trade Size and Smaller: Install pathways in maximum lengths of 50 feet.
 2. 1-Inch Trade Size and Larger: Install pathways in maximum lengths of 75 feet.
 3. Install with a maximum of two 90-degree bends or equivalent for each length of pathway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
- R. 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.
- S. 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.
- T. Comply with manufacturer's written instructions for solvent welding PVC conduit and fittings.
- U. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F, and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.
 3. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 4. 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.
- V. 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.

- W. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- 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.
- AA. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 270544 "Sleeves and Sleeve Seals for Communications Pathways and Cabling."

3.4 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage or deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 27 05 53

IDENTIFICATION FOR COMMUNICATIONS SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Color and legend requirements for labels and signs.
 - 2. Labels.
 - 3. Bands and tubes.
 - 4. Tapes.
 - 5. Signs.
 - 6. Cable ties.
 - 7. Fasteners for labels and signs.

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 communications identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule:
 - 1. Outlets: Scaled drawings indicating location and proposed designation.
 - 2. Backbone Cabling: Riser diagram showing each communications room, backbone cable, and proposed backbone cable designation.
 - 3. Racks: Scaled drawings indicating location and proposed designation.
 - 4. Patch Panels: Enlarged scaled drawings showing rack row, number, and proposed designations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Comply with NFPA 70 and TIA 606-B.
- B. Comply with ANSI Z535.4 for safety signs and labels.
- C. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.
- D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.
 - 1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

2.2 COLOR AND LEGEND REQUIREMENTS

- A. Equipment Identification Labels:
 - 1. Black letters on a white field.
 - 2. Patch Panels.

2.3 LABELS

- A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Champion America.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
- B. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
- C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil-thick, polyester or vinyl flexible labels with acrylic pressure-sensitive adhesive.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. LEM Products Inc.
 - c. Marking Services, Inc.
 2. 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.
 3. Marker for Labels: Permanent, waterproof black ink marker recommended by tag manufacturer.
 4. Marker for Labels: Machine-printed, permanent, waterproof black ink recommended by printer manufacturer.
- D. Self-Adhesive Labels: Polyester or Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.
 2. Minimum Nominal Size:
 - a. 1-1/2 by 6 inches for raceway and conductors.
 - b. 3-1/2 by 5 inches for equipment.
 - c. As required by authorities having jurisdiction.

2.4 BANDS AND TUBES

- A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameters sized to suit diameters of raceway or cable they identify, that stay in place by gripping action.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Brady Corporation.
 - b. HellermannTyton.
 - c. Marking Services, Inc.

2.5 CABLE TIES

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

1. HellermannTyton.
 2. Ideal Industries, Inc.
 3. Marking Services, Inc.
- B. General-Purpose Cable Ties: Fungus inert, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black, except where used for color-coding.
- C. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self-extinguishing, one piece, self-locking, and Type 6/6 nylon.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 12,000 psi.
 3. Temperature Range: Minus 40 to plus 185 deg F.
 4. Color: Black.
- D. Plenum-Rated Cable Ties: Self-extinguishing, UV stabilized, one piece, and self-locking.
1. Minimum Width: 3/16 inch.
 2. Tensile Strength at 73 deg F according to ASTM D 638: 7000 psi.
 3. UL 94 Flame Rating: 94V-0.
 4. Temperature Range: Minus 50 to plus 284 deg F.
 5. Color: Black.
- 2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS
- A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Self-Adhesive Identification Products: Before applying communications identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

- A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.
- B. Install identifying devices before installing acoustical ceilings and similar concealment.
- C. Verify identity of each item before installing identification products.
- D. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- E. Apply identification devices to surfaces that require finish after completing finish work.
- F. Install signs with approved legend to facilitate proper identification, operation, and maintenance of communications systems and connected items.
- G. Elevated Components: Increase sizes of labels, signs, and letters to those appropriate for viewing from the floor.
- H. Vinyl Wraparound Labels:
 - 1. Secure tight to surface of raceway or cable at a location with high visibility and accessibility.
 - 2. Attach labels that are not self-adhesive type with clear vinyl tape, with adhesive appropriate to the location and substrate.
 - 3. Provide label 6 inches from cable end.
- I. Snap-Around Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches from cable end.
- J. Self-Adhesive Wraparound Labels:
 - 1. Secure tight to surface at a location with high visibility and accessibility.
 - 2. Provide label 6 inches from cable end.
- K. Self-Adhesive Labels:
 - 1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
 - 2. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where two lines of text are required, use labels 2 inches high.
- L. Snap-Around, Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

M. Underground-Line Warning Tape:

1. During backfilling of trenches, install continuous underground-line warning tape directly above cable or raceway at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench [or concrete envelope] exceeds 16 inches overall.
2. Limit use of underground-line warning tape to direct-buried cables.
3. Install underground-line warning tape for direct-buried cables and cables in raceways.

N. Cable Ties: General purpose, except as listed below:

1. Outdoors: UV-stabilized nylon.
2. In Spaces Handling Environmental Air: Plenum rated.

3.3 IDENTIFICATION SCHEDULE

- A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.
- B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations with high visibility. Identify by system and circuit designation.
- C. 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 and outlets, starting at top left and working down, with self-adhesive labels.
 3. Data Outlets: Label each outlet with a self-adhesive label indicating the following, in the order listed:
 - a. Room number being served.

- b. Colon.
 - c. Faceplate number.
- F. Backbone Cables: Label each cable with a self-adhesive wraparound label indicating the location of the far or other end of the backbone cable. Patch panel or punch down block where cable is terminated should be labeled identically.
- G. Horizontal Cables: Label each cable with a self-adhesive wraparound label indicating the following, in the order listed:
 - 1. 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: Baked-enamel warning signs.
 - 1. Apply to exterior of door, cover, or other access.
- K. Equipment Identification Labels:
 - 1. Indoor Equipment: Self-adhesive label.
 - 2. 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

SECTION 27 15 13

COMMUNICATIONS COPPER HORIZONTAL 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. Category 6 twisted pair cable.
 - 2. Twisted pair cable hardware, including plugs and jacks.
 - 3. Cabling identification products.
 - 4. Grounding provisions for twisted pair cable.
 - 5. Source quality control requirements for twisted pair cable.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. FTP: Shielded twisted pair.
- C. F/FTP: Overall foil screened cable with foil screened twisted pair.
- D. F/UTP: Overall foil screened cable with unscreened twisted pair.
- E. IDC: Insulation displacement connector.
- F. LAN: Local area network.
- G. Jack: Also commonly called an "outlet," it is the fixed, female connector.
- H. Plug: Also commonly called a "connector," it is the removable, male telecommunications connector.
- I. RCDD: Registered Communications Distribution Designer.
- J. Screen: A metallic layer, either a foil or braid, placed around a pair or group of conductors.

- K. Shield: A metallic layer, either a foil or braid, placed around a pair or group of conductors.
- L. S/FTP: Overall braid screened cable with foil screened twisted pair.
- M. S/UTP: Overall braid screened cable with unscreened twisted pairs.
- N. UTP: Unscreened (unshielded) twisted pair.

1.4 COPPER HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable cabling system shall provide interconnections between Distributor A, Distributor B, or Distributor C, and the equipment outlet, otherwise known as "Cabling Subsystem 1," in the telecommunications cabling system structure. Cabling system consists of horizontal cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for horizontal-to-horizontal cross-connection.
 - 1. TIA-568-C.1 requires that a minimum of two equipment outlets be installed for each work area.
 - 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications equipment outlet.
 - 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately 100 sq. ft., and includes the components that extend from the equipment outlets to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Shop Drawings: Reviewed and stamped by RCDD.
 - 1. Cabling administration Drawings and printouts.
 - 2. Wiring diagrams and installation details of telecommunications equipment, to show location and layout of telecommunications equipment, including the following:
 - a. Telecommunications rooms plans and elevations.
 - b. Telecommunications pathways.
 - c. Telecommunications system access points.
 - d. Telecommunications grounding system.
 - e. Telecommunications conductor drop locations.
 - f. Typical telecommunications details.
 - g. Mechanical, electrical, and plumbing systems.

- C. Twisted pair cable testing plan.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For installer, installation supervisor, and field inspector.
- B. Product Certificates: For each type of product.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For splices and connectors to include in 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. Faceplates: One of each type per school.
 - 2. Jacks: 5 of each type per school.

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings and cabling administration Drawings by an RCDD.
 - 2. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.10 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test each pair of twisted pair cable for open and short circuits.

1.11 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568-C.1, when tested according to test procedures of this standard.
- B. Telecommunications Pathways and Spaces: Comply with TIA-569-D.
- C. Grounding: Comply with TIA-607-B.

2.2 GENERAL CABLE CHARACTERISTICS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with the applicable standard and NFPA 70 for the following types:
 - 1. Communications, Plenum Rated: Type CMP complying with UL 1685.
 - 2. Communications, Non-plenum: Type CMP or Type CMR in metallic conduit installed according to NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."
- B. Surface-Burning Characteristics: Comply with ASTM 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.
- C. RoHS compliant.

2.3 CATEGORY 6 TWISTED PAIR CABLE

- A. Description: Four-pair, balanced-twisted pair cable, with internal spline, certified to meet transmission characteristics of Category 6 cable at frequencies up to 250MHz.

- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden CDT Networking Division/NORDX.
 - 3. Draka USA.
- C. Standard: Comply with NEMA WC 66/ICEA S-116-732 and TIA-568-C.2 for Category 6 cables.
- D. Conductors: 100-ohm, 23 AWG solid copper.
- E. Shielding/Screening: Unshielded twisted pairs (UTP).
- F. Cable Rating: Plenum.
- G. Jacket: Blue thermoplastic.

2.4 TWISTED PAIR CABLE HARDWARE

- A. Description: Hardware designed to connect, splice, and terminate twisted pair copper communications cable.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AMP NETCONNECT; a TE Connectivity Ltd. company.
 - 2. Belden CDT Networking Division/NORDX.
 - 3. Draka USA.
- C. General Requirements for Twisted Pair Cable Hardware:
 - 1. Comply with the performance requirements of Category 6.
 - 2. Comply with TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools.
 - 3. Cables shall be terminated with connecting hardware of same category or higher.
- D. Source Limitations: Obtain twisted pair cable hardware from single source from single manufacturer.
- E. Connecting Blocks:
 - 1. 110-style IDC for Category 6.
 - 2. Provide blocks for the number of cables terminated on the block, plus 25 percent spare, integral with connector bodies, including plugs and jacks where indicated.
- F. Patch Panel: Modular panels housing numbered jack units with IDC-type connectors at each jack location for permanent termination of pair groups of installed cables.
 - 1. Features:

- a. Universal T568A and T568B wiring labels.
 - b. Labeling areas adjacent to conductors.
 - c. Replaceable connectors.
 - d. 24 or 48 ports.
 2. Construction: 16-gauge steel and mountable on 19-inch equipment racks.
 3. Number of Jacks per Field: One for each four-pair cable indicated.
- G. 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.
- H. Faceplate:
1. Two and Four port, vertical single gang faceplates designed to mount to single gang wall boxes.
 2. Plastic Faceplate: High-impact plastic. Coordinate color with architect.
 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.
- I. Legend:
1. Machine printed, in the field, using adhesive-tape label.
 2. Snap-in, clear-label covers and machine-printed paper inserts.
- 2.5 IDENTIFICATION PRODUCTS
- A. Comply with TIA-606-B and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- 2.6 GROUNDING
- A. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
 - B. Comply with TIA-607-B.
- 2.7 SOURCE QUALITY CONTROL
- A. Factory test twisted pair cables according to TIA-568-C.2.
 - B. Cable will be considered defective if it does not pass tests and inspections.

- C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays, except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, attics, and gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables, except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools. Install conductors parallel with or at right angles to sides and back of enclosure.

3.2 INSTALLATION OF PATHWAYS

- A. Comply with Section 260533 "Raceways and Boxes for Electrical Systems."
- B. Comply with Section 260529 "Hangers and Supports for Electrical Systems."
- C. Drawings indicate general arrangement of pathways and fittings.

3.3 INSTALLATION OF TWISTED-PAIR HORIZONTAL CABLES

- A. Comply with NECA 1 and NECA/BICSI 568.
- B. General Requirements for Cabling:
 - 1. Comply with TIA-568-C.0, TIA-568-C.1, and TIA-568-C.2.
 - 2. Comply with BICSI's "Information Transport Systems Installation Methods Manual (ITSIMM), Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section.
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Do not untwist twisted pair cables more than 1/2 inch from the point of termination to maintain cable geometry.
 - 5. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

6. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
7. Install lacing bars to restrain cables, prevent straining connections, and prevent bending cables to smaller radii than minimums recommended by manufacturer.
8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI Information Transport Systems Installation Methods Manual , Ch. 5, "Copper Structured Cabling Systems," "Cable Termination Practices" Section. Use lacing bars and distribution spools.
9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation, and replace it with new cable.
10. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
11. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
12. Pulling Cable: Comply with BICSI Information Transport Systems Installation Methods Manual, Ch. 5, "Copper Structured Cabling Systems," "Pulling and Installing Cable" Section. Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend twisted pair cabling, not in a wireway or pathway, a minimum of 8 inches above ceilings by cable supports not more than 36 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

D. Group connecting hardware for cables into separate logical fields.

E. Separation from EMI Sources:

1. Comply with recommendations from BICSI's "Telecommunications Distribution Methods Manual" and TIA-569-D for separating unshielded copper communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

- b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between communications cables in grounded metallic raceways, power lines, and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
- a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-D, Annex A, "Firestopping."
- C. Comply with "Firestopping Systems" Article in BICSI's "Telecommunications Distribution Methods Manual."

3.5 GROUNDING

- A. Install grounding according to the "Grounding, Bonding, and Electrical Protection" chapter in BICSI's "Telecommunications Distribution Methods Manual."
- B. Comply with TIA-607-B and NECA/BICSI-607.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall, allowing at least a 2-inch clearance behind the grounding bus bar. Connect grounding bus bar to suitable electrical building ground, using a minimum No. 4 AWG grounding electrode conductor.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than a No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA-606-B. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and

destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

- C. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- D. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if wire color is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip, and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group, extended from a panel or cabinet to a building-mounted device, with the name and number of a particular device.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and -connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- E. Labels shall be preprinted or computer-printed type, with a printing area and font color that contrast with cable jacket color but still comply with TIA-606-B requirements for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Visually inspect jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568-C.1.
 - 2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

3. Test twisted pair cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination.
 - a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similarly to Table 10.1 in BICSI's "Telecommunications Distribution Methods Manual," or shall be transferred from the instrument to the computer, saved as text files, printed, and submitted.
- D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

END OF SECTION

SECTION 28 05 13

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 SUMMARY

- A. Section Includes:
 - 1. Fire alarm wire and cable.
 - 2. Identification products.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. 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.
- E. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- F. RCDD: Registered Communications Distribution Designer.

1.4 ACTION SUBMITTALS

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

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- B. Source quality-control reports.

- C. Field quality-control reports.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
- B. Comply with the requirements of the Construction Indoor Air Quality Management Plan and the Construction Waste Management Plan.

1.8 PROJECT CONDITIONS

- A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
 - 1. Indications that wire and cables are wet, or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
- B. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- C. Waste Management: Comply with the requirements of the Construction Waste Management Plan.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

2.2 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Section 061000 "Rough Carpentry."

2.3 FIRE ALARM WIRE AND CABLE

- 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 or approved equal:
 - 1. Comtran Corporation.
 - 2. Draka Cableteq USA.
 - 3. Genesis Cable Products; Honeywell International, Inc.
 - 4. Rockbestos-Suprenant Cable Corp.
 - 5. West Penn Wire.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 16 AWG.
 - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
- 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.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum.
 - 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

2.4 IDENTIFICATION PRODUCTS

- 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 or approved equal:
 - 1. Brady Worldwide, Inc.
 - 2. HellermannTyton North America.
 - 3. Kroy LLC.
 - 4. Panduit Corp.

- B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Comply with requirements in Section 260553 "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
- C. Factory test UTP cables according to TIA/EIA-568-B.2.
- D. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.
- E. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
- F. Cable will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.2 WIRING METHOD

- A. Install wiring in metal pathways and wireways.
 - 1. Minimum conduit size shall be 3/4 inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Install cable, concealed in accessible ceilings, walls, and floors when possible.
- C. Wiring within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.
 - 2. Install lacing bars and distribution spools.
 - 3. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer.

4. Install conductors parallel with or at right angles to sides and back of enclosure.
5. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks.
6. Mark each terminal according to system's wiring diagrams.
7. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
- C. General Requirements for Cabling:
 1. Comply with TIA/EIA-568-B.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 3. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
 4. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 5. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 6. 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.
 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 8. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- D. Open-Cable Installation:
 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 2. Suspend copper cable 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.
- E. Separation from EMI Sources:
 1. Comply with BICSI TDM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
4. Separation between cables in grounded metallic raceways 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.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.4 FIRE ALARM WIRING INSTALLATION

- A. Comply with NECA 1 and NFPA 72.
- B. Wiring Method: Install wiring in metal raceway according to Section 260533 "Raceways and Boxes for Electrical Systems."
 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 raceway system. This system shall not be used for any other wire or cable.
- C. Wiring Method:
 1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
 2. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is not permitted.
 3. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

- D. 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.
- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. 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.
- G. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
- H. Wiring to Remote Alarm Transmitting Device: 1-inch 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.

3.5 POWER AND CONTROL-CIRCUIT CONDUCTORS

- A. 120-V Power Wiring: Install according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables" 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.

3.6 CONNECTIONS

- A. Comply with requirements in Section 283111 "Digital, Addressable Fire-Alarm System for connecting, terminating, and identifying wires and cables.

3.7 FIRESTOPPING

- A. Comply with requirements in Section 078413 "Penetration Firestopping."
- B. Comply with TIA-569-B, "Firestopping" Annex A.

- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.8 GROUNDING

- A. For communications wiring, comply with J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.10 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- C. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

SECTION 28 05 26

GROUNDING AND BONDING FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Grounding conductors.
 - 2. Grounding connectors.
 - 3. Grounding busbars.

1.3 DEFINITIONS

- A. Signal Ground: The ground reference point designated by manufacturer of the system that is considered to have zero voltage.

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Harger Lightning and Grounding.
 - 2. Panduit Corp.
 - 3. Tyco Electronics Corp.
- 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.
- D. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmils (14.2 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.

2.2 CONNECTORS

- A. Irreversible connectors listed for the purpose. Listed by an NRTL as complying with NFPA 70 for specific types, sizes, and combinations of conductors and other items connected. Comply with UL 486A-486B.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Burndy; Part of Hubbell Electrical Systems.
 - 2. Chatsworth Products, Inc.
 - 3. Harger Lightning and Grounding.
 - 4. Panduit Corp.
 - 5. Tyco Electronics Corp.
- C. Compression Wire Connectors: Crimp-and-compress connectors that bond to the conductor when the connector is compressed around the conductor. Comply with UL 467.
 - 1. Electroplated tinned copper, C and H shaped.
- D. Busbar Connectors: Cast silicon bronze, solderless compression-type mechanical connector; with a long barrel and two holes spaced on 5/8- or 1-inch (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.

2.3 GROUNDING BUSBARS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Chatsworth Products, Inc.
 2. Harger Lightning and Grounding.
 3. Panduit Corp.
- B. Grounding Busbars: 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 J-STD-607-A.
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.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
1. 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.
 2. Bond shields and drain conductors to ground at only one point in each circuit.
- B. Signal Ground:
1. For each system, establish the signal ground and label that location as such.
 2. Bond the signal ground to the alternating-current (ac) power system service by connecting to one of the following listed locations, using insulated No. 6 AWG, stranded, Type THHN wire:
 - a. Grounding bar in an electrical power panelboard if located in the same room or space as the signal ground.
 - b. Telecommunications grounding busbar.

- C. Comply with NECA 1.

3.2 APPLICATION

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. 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.

3.3 CONNECTIONS

- A. Stacking of conductors under a single bolt is not permitted when connecting to busbars.
- B. 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. Pre twist the conductor.
 - 3. Apply an antioxidant compound to all bolted and compression connections.
- C. Shielded Cable: Bond the shield of shielded cable to the signal ground. Comply with TIA/EIA-568-B.1 and TIA/EIA-568-B.2 when grounding screened, balanced, twisted-pair cables.
- D. 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.

3.4 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.

- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION

SECTION 28 31 13

FIRE DEPARTMENT AUXILIARY RADIO COMMUNICATION SYSTEM

PART 1 – GENERAL

1.1 RELATED WORK

- A. Design, Furnish and install Fire Department in-building auxiliary radio communication system, including all equipment and accessories as specified herein and as required by the code as indicated on and in accordance with the requirements of the Contract Documents.
- B. Section includes:
 - 1. Power supply
 - 2. Dedicated Radio Console (DRC)
 - 3. Radio Amplification Unit (RAU)
 - 4. Cabling and Antenna Plant (CAP)
 - 5. Uplink Radio Propagation
 - 6. Downlink Radio Propagation
 - 7. System Monitoring

1.2 REFERENCES

- A. The complete fire alarm and detection system and all components shall be designed, manufactured, tested, and installed in accordance with the latest applicable codes and reference standards including the following:
 - 1. Codes: Perform all work in accordance with the latest applicable codes and standards for New York State.
 - a. BCNYS: Building Code of New York State.
 - b. FDNY: New York Fire Department
 - c. NFPA 72: National Fire Alarm Code with BCCNYS Amendments.
 - d. NFPA 101: Life Safety Code.
 - e. NYSEC: New York State Electrical Code
 - f. NYSFC: New York State Fire Code.
 - g. NYS DOB Buildings Bulletin 2011-013
 - h. FCC Part 90
- B. The system and its components shall be UL listed. The equipment and installation shall comply with all local codes and authorities having jurisdiction, including, but not limited to New York State Building Code, New York State Electrical Code, and the New York State Fire Code. Where the local standards vary from UL and NFPA standards previously referenced, the local standard takes precedence.

- C. Where federal standards vary from UL and NFPA and local standards, the federal standards shall take precedence.

1.3 QUALITY ASSURANCE

- A. This system shall be provided as part of the fire alarm and detection system. The fire alarm and detection system vendor shall subcontract this vendor and provide all oversight, coordination, etc.
- B. All products and components used on this specification shall be:
 - 1. New and free of manufacturing defects.
 - 2. In compliance with the FCC Part 90 Public Safety LMR regulations, including the 2013 FCC narrow banding mandate.
 - 3. Free of storage and handling damage.
 - 4. Clearly and permanently labeled "FDNYS Communications Use," or "FDNYS ARCS RADIO."
 - 5. Electrical components shall be rated to operate at +20% and -10% of rated voltage, unless otherwise specified.
- C. The absence of any details in this specification implies that the best general practice shall prevail, and first-quality material and workmanship shall be employed throughout. Including compliance with Federal and Local laws and policy.
- D. All equipment and material to be furnished and installed on this project shall be the product of a manufacturer(s) which contractor is an authorized reseller and suitable for its intended use on this project.
- E. Before commencing work, submit data showing that the contractor has successfully installed systems of the same scope, type and design as specified. Include the names and locations of at least three (3) installations where such systems have performed satisfactorily for the preceding eighteen (18) months.
- F. The contractor is to be certified and experienced in the installation and operation of the type of system provided. The contractor shall have technical personal who are certified to supervise installation, software programming, software documentation, adjustments, preliminary testing and provide operation instruction to the Owner's personnel. Instruction shall include system operation, maintenance, and programming and activation procedures.
- G. The equipment manufacturer shall have been engaged in the production of this type of equipment for at least ten (10) years and have fully equipped service organization capable of responding to the project site within four (4) hours from the initial contract for warranty or regular service work. Emergency and/or off-hours calls shall be responded to within four (4) hours of initial contact seven (7) days a week.

1.4 SUBMITTALS

- A. Provide the following submittal data according to the conditions of the base document specification and describe the proposed system and its equipment. The complete submittal shall include, but not be limited to, all the following material:
1. Proposed System Narrative Description:
 - a. Active or Passive Cabling and Antenna Plant
 - b. Proposed Radio Amplifier Unit (RAU) Features and Functionality
 - c. Proposed Dedicated Radio Console (DRC) Features and Functionality
 - d. Agency and House Radio Support and Frequency Allocations
 - e. Site specific radio intermodulation report.
 - f. Sample Certification Test Result, Acceptance Test Procedure (ATP) for the following:
 - (i) Radio Amplification Unit ATP
 - (ii) Dedicated Radio Console ATP
 - (iii) Cabling and Antenna Plant ATP
 - (iv) Power Supply ATP
 - g. Power Calculations
 - (i) Battery Capacity Calculations
 - (ii) Power Requirements for all equipment during communication operation.
 - (iii) Power supply rating justification showing power requirements for each of the system power supplies.
 - (iv) Voltage drop calculations for wiring runs demonstrating a worst-case condition.
 - (v) Panel ampere loading, for the system control panel and power supply during both standby and transmit and receive modes with time calculations to substantiate compliance with battery back-up power requirements.
 2. Complete manufacturer's catalog data including physical dimensions, finish and mounting requirements.
 3. Address, telephone number, and contact person(s) of the contractor's local services facility for normal and off-hour warranty issues.

4. Submit a paragraph-by-paragraph letter of compliance (of this specification) identifying compliance or non-compliance and reasons for non-compliance.
5. Provide a Service Contract Proposal, to include:
 - a. Annual ARCS certification test.
 - b. Annual ARCS certification filing and administrative charges.
 - c. Quarterly preventative maintenance.
 - d. Cost inclusive of four (4) hour emergency response and corrective actions for emergency repairs.
 - e. Pricing options provided in twelve (12), thirty six (36) and, sixty (60) month options.
6. All submittal data shall be in bound form with this Contractor's name and project name.
7. No matter how minor, any deviations from these specifications shall be submitted in written form to be reviewed by the engineer. Complete drawings and itemizations of deviations shall be included.
8. Bid submission must include statement from the proposing firm's intended engineer of record for the system.

1.5 UNIT PRICES

- A. Provide unit prices as part of the proposal in accordance with the following schedule and the requirements of Section 28311.
 1. Additional Engineering Hours \$ _____/l.h.
 2. Additional Dedicated Radio Console (DRC) \$ _____/e.a.
 3. Additional Radio Amplification Unit (RAU) \$ _____/e.a.
 4. Additional ARCS Certification Hours \$ _____/l.h.

1.6 WARRANTY, MAINTENANCE AND SERVICE CONTRACT

- A. Provide two (2) years of system maintenance and service herein called the "MS package. Provide a separate price for this package as part of the bid proposal. The MS package is to include performance in testing during the two (2) year service contract. This instruction and testing shall take place during the schedule preventive maintenance periods.
- B. Provide a training course for building operators of the system, with personal on-the-job instruction provided by a manufacturer certified person.
- C. The operators shall be trained in the operation and preventive maintenance of the entire system. The operators shall be trained to recognize malfunctions of the control center by observations of printed copy and visual and audible signals. The instructions for accomplishing this and the instructions for the corresponding action to be taken shall be included in the operator's manual.

- D. In addition to the electronic media requirement, providing five (5) complete hard copy sets of the following:
 - 1. Written operating and maintenance instructions.
 - 2. Specifications, data sheets and maintenance schedules.
- E. Warrant the continuous future availability of service for this system. The servicing shall be provided by a factory trained service representative.
- F. Provide technical instructions on trouble-shooting, maintenance and all FDNY-required daily and yearly testing during the two (2) year service contract. This instruction shall take place during the scheduled preventive maintenance periods.
- G. Warranty and Service Contract period shall take effect with owner's acceptance of the ARCS installation.
- H. Submit a letter of approval of the installation from the local code authority before requesting final acceptance of the system.

1.7 TOOLS AND SPARE PARTS

- A. All special tools and spare parts required for operation and maintenance of equipment shall be furnished and delivered to the Owner or his representatives, and a receipt obtained prior to or at the time of instructions to operating personnel.
- B. A list of the specified tools and spare parts to be supplied shall be detailed in the technical proposal.

PART 2 - PRODUCTS AND SERVICES

2.1 ACCEPTABLE MANUFACTURERS

- A. All substitutions must be identified in the Base Bid as a voluntary Deduct Alternate, and must be accompanied by a Letter of Equivalency certifying the product's equivalency in all performance and physical characteristics to the products listed herein. The proposed substitutions shall be inclusive of all cost and physical implications through the project. Under no circumstances should the substitution result in added cost to the project. Should the substitution be approved neither the project specifications nor the Contract Documents will be revised to reflect the substitution.
- B. If it complies with the Contract Documents, a Dedicated Radio Console (DRC) from TOWERIQ or equivalent.
- C. If it complies with the Contract Documents, a Radio Amplification Unit (RAU) from TOWERIQ or equivalent.
- D. If it complies with the Contract Documents, Cabling and Antenna Plant (CAP) components from the following manufacturers will be acceptable:

1. TOWERIQ
2. Cellular Specialties
3. CommScope/Andrews
4. Comtelco
5. Hansen
6. Laird/Antenex
7. Maxrad/PCTEL
8. MECA
9. Microlab
10. RFS
11. Telewave
12. Trilogy Communications

2.2 GENERAL

- A. This Contractor design, furnish, install, certify and place in operating condition a complete Auxiliary Radio Communication System. The system shall include, but not be limited to, all control equipment including dedicated radio console(s), radio amplification unit(s), antennae, coaxial cable, communications and control cable, radiating coaxial cable, terminations, resistive loads, power supplies, hardware, software, conduit, wire fittings, and all other accessories required to meet code and provide a complete and operable system whether or not specifically expressed herein.
- B. Provide "Engineer of Record" for system engineering and certification.
- C. Obtain a copy of the FDNY technical documents for its specific requirements and integrate into the design of the system, including but not limited to the following:
 1. Frequencies Required

2.3 FILING

- A. Prepare and file as engineer of record the NYS Department of Buildings form "PW1" for job permit application.
- B. Prepare and file as engineer of record the NYS Fire Prevention form "TM1" for system review.
- C. Prepare and file as engineer of record an additional NYS Fire Prevention form "TM1" for certification test result review.
- D. Prepare and file as engineer of record the NYS Department of Buildings form "B45m" and any additional filings to request Fire Prevention inspection of installation and approval.
- E. Building ownership is to be provided with copies of all formal submittals and correspondence. Including but not limited to:
 1. System Design Narrative

2. Detailed Statement of Operations
3. Shop Drawings for Installation
4. As Built Drawings
5. Certification Test Report(s)
6. Certification Test Drawing(s)

2.4 POWER SUPPLY

- A. System Power supplies shall be provided, including necessary transformer rectifiers, regulators, filters and surge protection to render the system impervious to any variation in input power quality, including surges, transients, under voltage, line noise, harmonics, etc., whether originating from the building primary power or generator power required for system operation.
- B. Primary Power Supply: Power shall be derived from the same source as the fire alarm and detection system. The components shall be sized as required for the full load requirement of all systems severed from this source.
- C. Size all wiring based on expected maximum load so as not to exceed the maximum voltage drop required within the NYSEC for feeders and branch circuits.
- D. Secondary Power Supply: When a secondary power source is available, the system shall derive power from that additional source. The components shall be sized as required for the full load requirement of all systems severed from this source.
- E. Local Battery Backup: Provide localized battery backup derived, utilizing sealed gelled electrolyte batteries. The battery supply shall be sized to provide twelve (12) hours of continuous, normal, operation for all system components.
- F. Power Source: All ARCS components shall seamlessly switch from power source, with no interruption or reduction of operating capabilities, according to the following source preference:
 1. Primary Power Supply
 2. Secondary Power Supply
 3. Battery Backup
- G. Recharge Cycle: the battery backup power supply shall be fully charged within forty eight (48) hours of operation.

2.5 DEDICATED RADIO CONSOLE

- A. The radio console shall be mounted adjacent, or in close proximity to, the fire alarm control panel and shall simultaneously control two (2) sets of frequencies for a repeating based system and have selectable control of at least two (2) simplex frequencies.
- B. The dedicated radio console shall be hardwired to with supervisory and priority interrupt control of the radio amplification units.

- C. The dedicated radio console shall be capable of operating in the following modes:
 - 1. Standby
 - 2. Monitoring, receiving signal only.
 - 3. Active, transmitting and receiving signal, with supervisory control.
- D. Provide a 2642 keyed control switch, which will be utilized for energizing the ARCS system.
- E. Dedicated Radio Console shall provide annunciation indicating operating status for the following conditions:
 - 1. Standby
 - 2. Monitoring
 - 3. Active
 - 4. Transmitting
 - 5. Receiving
 - 6. AC Power Active
 - 7. Battery Power Active
 - 8. Low Battery Alert

2.6 RADIO AMPLIFICATION UNIT

- A. The fire department in-building Auxiliary Radio Communication System shall be capable of transmitting all fire department frequencies assigned to the jurisdiction and be capable of using any modulation technology.
- B. The FDNY channel frequencies will be provided upon agreement to install Repeater/Simplex System.
- C. The repeater/simplex system shall only be capable of operating in 12.5 KHz (analog and digital) operations.
- D. The system shall be capable of upgrade to allow for instances where the jurisdiction changes or adds system frequencies, in order to maintain radio system coverage as originally designed.
- E. Simplex (Ch. 1 through Ch. 9)
 - 1. Signaling transmitted by the portable radios for ID and Emergency shall be displayed at the dedicated radio console of the simplex system.
- F. Repeating (Ch. 11 and Ch. 12)
 - 1. Signaling transmitted by the portable radios for ID and Emergency Alert signals shall pass through the repeater and rebroadcast to all receiving radios in the coverage umbrella of the building's CAP.

- G. No amplification system installed in the building shall cause interference to the auxiliary radio communications system. The building owner shall suspend or correct any operations detected to cause interference.
- H. Radio Amplification Unit shall be FCC certified prior to installations.
- I. All Radio Amplification Unit shall have both digital and analog communications compatibilities at the time of installation.
- J. The Radio Amplification Unit shall not cause PIM or TDI interference.
- K. The Radio Amplification Unit shall not inject power into the CAP at greater than 2W or 33dBm.

2.7 CABLING AND ANTENNA PLANT (CAP)

- A. Building Coverage Umbrella: Defined as the floor area and exterior street level area where FDNY radio signal coverage generated from the building's installed auxiliary radio communication system equipment is greater than the -93dBm signal strength requirement.
- B. CAP Shall be engineered to limit the building coverage umbrella to a one (1) block radio surrounding the building.
- C. CAP shall be engineered to provide the following coverage to each building floor.
 - 1. Received Signal Strength Indication (RSSI) of greater than -93dBm to 97% of the floor, 95% of the time.
 - 2. Delivered Audio Quality (DAQ) of greater than 3.4 to 97% of the floor.
- D. CAP shall be engineered to provide the following coverage to building critical areas.
 - 1. Received Signal Strength Indication (RSSI) of greater than -93dBm to 97% of the floor, 95% of the time.
 - 2. Delivered Audio Quality (DAQ) of greater than 3.4 to 97% of the floor.

2.8 UPLINK/DOWNLINK RADIO PROPAGATION

- A. Uplink, the fire fighter portable radio to the radio amplification unit, shall be greater than the Downlink, the radio amplification unit to the fire fighter portable radio.
 - 1. The portable radio is expected to transmit at a minimum of 2W, or 33dBm.
 - 2. The Radio Amplification Unit may not generate signal at a level greater than 2W or 33dBm.

2.9 SYSTEM MONITORING

- A. The ARCS system shall be capable of monitoring the following conditions:

1. Standby Mode
2. Monitor Mode
3. Active Mode
4. AC Power
5. Battery Backup
6. Low Battery
7. Power Supply Fault
8. RAU Fault
9. CAP Fault
10. Door Open
11. High Temperature
12. Water Detected.

- B. Status Reports: Upon command from an operator of the system, a status report will be generated and printed, listing all system status.
- C. The system will automatically poll itself daily, capable of sending SMTP based alerting to a designated email address.
- D. The ARCS system shall be capable of transmitting system status to a UL-listed central station or manufacturer via internet protocol.

2.10 CERTIFICATION TESTING

- A. Contractor will perform all testing required by Fire Prevention to certify the building as ARCS certified.
- B. Prior to the commencement of the certification test, contractor will develop and submit an accepted test procedure (ATP) for each of the following:
 1. Dedicated Radio Console Functionality
 2. Amplified Radio Unit Functionality
 3. Power Supply Functionality
 4. Cabling and Antenna Plant Propagation and Functionality
- C. Prior to the commencement of the certification test, contractor will coordinate with building management access to all building facilities, developing a suitable schedule.

END OF SECTION

SECTION 28 46 21.11

ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
2. Manual fire-alarm boxes.
3. System smoke detectors.
4. Air-sampling smoke detectors.
5. Heat detectors.
6. Notification appliances.
7. Device guards.
8. Magnetic door holders.
9. Remote annunciator.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.
13. Network communications.

B. Related Requirements:

1. Section 271513 "Communications Copper Horizontal Cabling" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

- A. EMT: Electrical Metallic Tubing.
- B. FACP: Fire Alarm Control Panel.
- C. HLI: High Level Interface.
- D. NICET: National Institute for Certification in Engineering Technologies.
- E. PC: Personal computer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.
12. 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.
13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.
 - b. NICET-certified, fire-alarm technician; Level III minimum.
 - c. Licensed or certified by authorities having jurisdiction.

- D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Drawings showing the location of each notification appliance and smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the device.
 - 2. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72. Calculate spacing and intensities for strobe signals and sound-pressure levels for audible appliances.
 - 3. Indicate audible appliances required to produce square wave signal per NFPA 72.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Field quality-control reports.

1.6 Sample Warranty: For special warranty.

1.7 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.

1.8 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 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, Heat Detectors, and Carbon Monoxide 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 tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.
8. Provide all necessary hardware and programming to provide the client with 20% spare capacity on all initiating and indicating circuits.
9. Provide as part of the base contract all labor and materials to install twenty (20) additional fire alarm devices during construction. The twenty (20) fire alarm device can be but not limited to smoke detector, heat detector, door holder, duct detector, fan shutdown, tamper switches, flow switches, etc. Include all labor and materials including wire, boxes, conduit, terminations, hardware, software, programming and testing.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

- B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.
- C. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.10 PROJECT CONDITIONS

- A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 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 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:
 - 1. Manual stations.
 - 2. Heat detectors.

3. Smoke detectors.
 4. Duct smoke detectors.
 5. Carbon monoxide detectors.
 6. Automatic sprinkler system water flow.
- 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, connected network control panels, off-premises network control panels, 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. Recall elevators to primary or alternate recall floors.
 10. Activate elevator power shunt trip.
 11. Record events in the system memory.
 12. Override Cafeteria PA Sound System.
 13. Override Gym PA Sound System.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
 2. Elevator shunt-trip supervision.
 3. User disabling of zones or individual devices.
 4. 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. Initiate notification appliances.
2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.
3. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.
4. Transmit system status to building management system.

2.3 FIRE-ALARM CONTROL UNIT

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

1. GE UTC Fire & Security; A United Technologies Company.
2. Notifier.
3. Honeywell International (Fire-Lite Alarms).
4. SimplexGrinnell LP.
5. Mircom Technologies, Ltd.
- 6.

- 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, 80 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- D. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, three line(s) of 80 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
- E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:
1. Pathway Class Designations: NFPA 72, Class B.
 2. Pathway Survivability: Level 1.
 3. Install no more than 100 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 port for PC configuration.
 - d. One RS 232 port for voice evacuation interface.
- F. Notification-Appliance Circuit:
1. Fire Alarm Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72. Carbon Monoxide Alarm Audible appliances shall sound in a four pulse temporal pattern or a constant tone. Carbon monoxide Alarm tone shall be different than the Fire Alarm tone.
 2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
 3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- 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. Heat Detectors in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
- 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.
- J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- K. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals 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.
- L. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
1. Batteries: Sealed lead calcium Sealed, recombinant lead acid] Vented, wet-cell pocket, plate nickel cadmium.
- M. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 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. GE UTC Fire & Security; A United Technologies Company.
 2. Notifier.
 3. Siemens Industry, Inc.; Fire Safety Division.
 4. SimplexGrinnell LP.
- 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 attached 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.

2.5 SYSTEM SMOKE DETECTORS

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

1. GE UTC Fire & Security; A United Technologies Company.
2. Notifier.
3. Siemens Industry, Inc.; Fire Safety Division.
4. SimplexGrinnell LP.

- B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type, indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. Multiple levels of detection sensitivity for each sensor.
 - b. 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.).

D. 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. Each sensor shall have multiple levels of detection sensitivity.
4. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
5. Relay Fan Shutdown: Fully programmable relay rated to interrupt fan motor-control circuit.

2.6 PROJECTED BEAM SMOKE DETECTORS

- A. Projected Beam Light Source and Receiver: Designed to accommodate small angular movements and continue to operate and not cause nuisance alarms.
- B. Detector Address: Accessible from fire-alarm control unit and able to identify the detector's location within the system and its sensitivity setting.
- C. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 1. Primary status.
 2. Device type.
 3. Present average value.
 4. Present sensitivity selected.
 5. Sensor range (normal, dirty, etc.).

2.7 CARBON MONOXIDE DETECTORS

- A. General: Carbon monoxide detector listed for connection to fire-alarm system.
 1. Mounting: Adapter plate for outlet box mounting.
 2. Testable by introducing test carbon monoxide into the sensing cell.
 3. Detector shall provide alarm contacts and trouble contacts.
 4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.
 5. Comply with UL 2075.
 6. Locate, mount, and wire according to manufacturer's written instructions.
 7. Provide means for addressable connection to fire-alarm system.
 8. Test button simulates an alarm condition.
 9. Provide with sounder bases for local audio annunciator.

2.8 MULTICRITERIA DETECTORS

- A. Mounting: Twist-lock base interchangeable with smoke-detector bases.
- B. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- C. Automatically adjusts its sensitivity by means of drift compensation and smoothing algorithms. The detector shall send trouble alarm if it is incapable of compensating for existing conditions.
- D. Test button tests all sensors in the detector.
- E. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - 1. Primary status.
 - 2. Device type.
 - 3. Present sensitivity selected.
 - 4. Sensor range (normal, dirty, etc.).
- F. Sensors: The detector shall be comprised of four sensing elements including a smoke sensor, a carbon monoxide sensor, an infrared sensor, and a heat sensor.
 - 1. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.
 - 2. Carbon monoxide sensor shall be as described in "Carbon Monoxide Detectors" Article.
 - 3. Heat sensor shall be as described in "Heat Detectors" Article.
 - 4. Each sensor shall be separately listed according to requirements for its detector type.

2.9 HEAT DETECTORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. GE UTC Fire & Security; A United Technologies Company.
 - 2. Notifier.
 - 3. Siemens Industry, Inc.; Fire Safety Division.
 - 4. SimplexGrinnell LP.
- 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.

2.10 AIR-SAMPLING SMOKE DETECTOR

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

1. Ansul by Johnson Controls Company.
2. Fenwal Protection Systems; A UTC Fire & Security Company.
3. Fike Corporation.
4. Notifier.

- B. General Description:

1. Air-sampling smoke detector shall be laser based using a piping system and a fan to transport the particles of combustion to the detector.
2. Provide two levels of alarm from each zone covered by the detector and two supervisory levels of alarm from each detector.
3. The air being sampled shall pass through filters to remove dust particulates greater than 20 microns before entering the detection chamber.
4. Detectors shall have the capability via RS 485 to connect up to 100 detectors in a network.
5. Detectors shall communicate with the fire-alarm control unit via addressable, monitored dry contact closures, RS 485, and interface modules. Provide a minimum of six relays, individually programmable remotely for any function.
6. Pipe airflow balancing calculations shall be performed using approved calculation software.

- C. Detector:

1. Detector, Filter, Aspirator, and Relays: Housed in a mounting box and arranged in such a way that air is drawn from the detection area and a sample passed through the dual-stage filter and detector by the aspirator.
2. Obscuration Sensitivity Range: 0.005 - 6 percent obs/ft.
3. Four independent, field-programmable, smoke-alarm thresholds per sensor pipe and a programmable scan time delay. The threshold set points shall be programmable.
 - a. The four alarm thresholds may be used as follows:
 - 1) Alarm Level 1 (Alert): Activate a visual and an audible supervisory alarm.
 - 2) Alarm Level 2 (Action): Activate shutdown of electrical/HVAC equipment and activate a visual and an audible supervisory alarm.
 - 3) Alarm Level 3 (Fire 1): Activate building alarm systems and initiate call to fire response unit.
 - 4) Alarm Level 4 (Fire 2): Activate suppression system or other countermeasures.

- b. Final Detection System Settings: Approved by Architect.
 - c. Initial Detection Alarm Settings:
 - 1) Alarm Level 1 (Alert): 0.08 percent obs/ft.
 - 2) Alarm Level 2 (Action): 1.0 percent obs/ft.
 - 3) Alarm Level 3 (Fire 1): 2.0 percent obs/ft.
 - 4) Alarm Level 4 (Fire 2): 4.0 percent obs/ft.
 - 4. Power Supply:
 - a. Regulated 24-V dc, monitored by the fire-alarm control unit, with battery backup.
 - b. Battery backup shall provide 24 hours' standby, followed by 30 minutes at maximum connected load.
 - 5. Detector shall also transmit the following faults:
 - a. Detector.
 - b. Airflow.
 - c. Filter.
 - d. System.
 - e. Zone.
 - f. Network.
 - g. Power.
 - 6. Provide four in-line sample pipe inlets that shall contain a flow sensor for each pipe inlet. The detector shall be capable of identifying the pipe from which smoke was detected.
 - 7. Aspirator: Air pump capable of allowing for multiple sampling pipe runs up to 650 feet (200 m) in total, (four pipe runs per detector) with a transport time of less than 120 seconds from the farthest sample port.
 - 8. Air-Sampling Flow Rates Outside Manufacturer's Specified Range: Result in a trouble alarm.
 - 9. Provide software-programmable relays rated at 2 A at 30-V dc for alarm and fault conditions.
 - 10. Provide built-in event and smoke logging; store smoke levels, alarm conditions, operator actions, and faults with date and time of each event. Each detector (zone) shall be capable of storing up to 18,000 events.
 - 11. Urgent and Minor Faults. Minor faults shall be designated as trouble alarms. Urgent faults, which indicate the unit may not be able to detect smoke, shall be designated as supervisory alarms.
- D. Displays:
- 1. Include display module within each detector.
 - 2. Each display shall provide the following features at a minimum:
 - a. A bar-graph display.
 - b. Four independent, high-intensity alarm indicators (Alert, Action, Fire 1, and Fire 2), corresponding to the four alarm thresholds of the indicated sector.
 - c. Alarm threshold indicators for Alert, Action, and Fire 1.

- d. LED indication that the first alarm sector is established.
- e. Detector fault and airflow fault indicators.
- f. LED indicators shall be provided for faults originating in the particular zone (Zone Fault), faults produced by the overall smoke-detection system, and faults resulting from network wiring errors (Network Fault).
- g. Minor and urgent LED fault indicators.

E. Sampling Tubes:

- 1. Smooth bore with a nominal 1-inch (25-mm) OD and a 7/8-inch (21-mm) ID. Sampling pipe with between 5/8- and 1-inch (15- and 25-mm) ID can be used in specifically approved locations when recommended by manufacturer.
- 2. Pipe Material: CPVC and complying with UL 1887, "Safety Fire Test of Plastic Sprinkler Pipe for Visible Flame and Smoke Characteristics."
- 3. Joints in the sampling pipe shall be airtight. Use solvent cement approved by the pipe manufacturer on all joints except at entry to the detector.
- 4. Identify piping with labels reading: "Aspirating Smoke Detector Pipe - Do Not Paint or Disturb" along its entire length at regular intervals according to NFPA 72.
- 5. Support pipes at not more than 60-inch (1520-mm) centers.
- 6. Fit end of each trunk or branch pipe with an end cap and drilled with a hole appropriately sized to achieve the performance as specified and as calculated by the system design.

F. Sampling Holes:

- 1. Sampling holes of 5/64 inch (2 mm), or other sized holes per manufacturer's written instructions, shall be separated by not more than the maximum distance allowable for conventional smoke detectors. Intervals may vary according to calculations.
- 2. Follow manufacturer's written recommendations to determine the number and spacing of sampling points and the distance from sampling points to ceiling or roof structure and to forced ventilation systems.
- 3. Each sampling point shall be identified by an applied decal.

2.11 NOTIFICATION APPLIANCES

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

- 1. GE UTC Fire & Security; A United Technologies Company.
- 2. Siemens Industry, Inc.; Fire Safety Division.
- 3. SimplexGrinnell LP.
- 4. System Sensor.

B. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
- C. 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 177cd.
 - b. 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, red.
- D. 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: surface mounted and bidirectional.
 6. Matching Transformers: Tap range matched to acoustical environment of speaker location.
- E. 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.

2.12 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: 24-V ac or dc.

4. Rating: 120-V ac.

- B. Material and Finish: Match door hardware.

2.13 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: 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.

2.14 ADDRESSABLE INTERFACE DEVICE

- A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
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.

2.15 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45

seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.
 - 4. Manual test report function and manual transmission clear indication.
 - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 - 1. Address of the alarm-initiating device.
 - 2. Address of the supervisory signal.
 - 3. Address of the trouble-initiating device.
 - 4. Loss of ac supply.
 - 5. Loss of power.
 - 6. Low battery.
 - 7. Abnormal test signal.
 - 8. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.16 RADIO ALARM TRANSMITTER

- A. Transmitter shall comply with NFPA 1221 and 47 CFR 90.
- B. Description: Manufacturer's standard commercial product; factory assembled, wired, and tested; ready for installation and operation.
 - 1. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
 - 2. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
 - 3. Normal Power Input: 120-V ac.
 - 4. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
 - 5. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph (160 km/h) with a gust factor of 1.3 without failure.

6. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
 7. Antenna-Cable Connectors: Weatherproof.
 8. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
- C. Functional Performance: Unit shall receive alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:
1. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
 2. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
 3. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
 4. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
 5. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
 6. Local Fire-Alarm-System, Supervisory-Alarm Message:

2.17 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 Modbus for connection to building automation system.

2.18 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. 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.
- C. 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.
- D. 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.
- E. 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.
- F. Air-Sampling Smoke Detectors: If using multiple pipe runs, the runs shall be pneumatically balanced.
- G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
- H. 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.
- I. 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.
- J. 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.
- K. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- L. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph (160-km/h) wind load with a gust factor of 1.3 without damage.

3.3 PATHWAYS

- A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.
1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

- B. Pathways shall be installed in EMT.
- C. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.
 - 1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
 - 1. Smoke dampers in air ducts of designated HVAC duct systems.
 - 2. Magnetically held-open doors.
 - 3. Electronically locked doors and access gates.
 - 4. Alarm-initiating connection to elevator recall system and components.
 - 5. Supervisory connections at valve supervisory switches.
 - 6. Supervisory connections at elevator shunt-trip breaker.

3.5 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

- C. Perform tests and inspections.
- D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
 - b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.
- H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
- I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 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