Prepared for:
Midwestern State University
Wichita Falls, Texas

Mass Communications Project

MEP and Civil

BID DOCUMENTS
SEPTEMBER 21, 2015
REES PROJECT No. 21503.00

REES
ARCHITECTURE PLANNING INTERIORS
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DIVISION 21 - FIRE SUPPRESSION

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FIRE SPRINKLER SYSTEM

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Pipes, fittings, and specialties.
   2. Sprinklers.
   3. Pressure Gages.
B. Related Sections:
   1. Division 28 Section "Digital, Addressable Fire Alarm System" for alarm devices not specified in this section.

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

1.4 SYSTEM DESCRIPTIONS
A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.
B. This project involves the revisions to an existing wet-pipe system required to accommodate the interior renovation indicated on the drawings.

1.5 PERFORMANCE REQUIREMENTS
A. Standard-Pressure Piping System Component: Listed for 175-psig (1200-kPa) minimum working pressure.
B. Delegated Design: Design sprinkler system(s), including comprehensive engineering analysis by a licensed Fire Sprinkler Contractor, using performance requirements and design criteria indicated.

1. Contractor shall obtain recent fire-hydrant flow test records, or perform a flow test, prior to the start of design and shall use this data as the basis of design.

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

1. Margin of Safety for Available Water Flow and Pressure: 10 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:
   a. Building Service Areas: Ordinary Hazard, Group 1
   b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
   c. General Storage Areas: Ordinary Hazard, Group 1.
   d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
   e. Office and Public Areas: Light Hazard.
   f. Computer Rooms: Light Hazard.
3. Minimum Density for Automatic-Sprinkler Piping Design:
   a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. (4.1 mm/min. over 139-sq. m) area.
   b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. (6.1 mm/min. over 139-sq. m) area.
4. Maximum Protection Area per Sprinkler: Per UL listing.
5. Total Combined Hose-Stream Demand Requirement: According to NFPA 13 unless otherwise indicated:
   a. Light-Hazard Occupancies: 100 gpm (6.3 L/s) for 30 minutes.
   b. Ordinary-Hazard Occupancies: 250 gpm (15.75 L/s) for 60 to 90 minutes.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

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

1. Wiring Diagrams: For power, signal, and control wiring.

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

D. Coordination Drawings: Sprinkler systems, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
1. Domestic water piping.
2. Compressed air piping.
3. HVAC hydronic piping.
4. Items penetrating finished ceiling include the following:
   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Smoke detectors and other ceiling mounted devices.

E. Qualification Data: For qualified installer and professional engineer.

F. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations if applicable.

G. Welding certificates.

H. Fire-hydrant flow test report - performed within the last three months.

I. 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."

J. Field quality-control reports.

K. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: 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.

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

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

D. NFPA Standards: Sprinkler system equipment, specialties, accessories, installation, and testing shall comply with the following:
   1. NFPA 13, "Installation of Sprinkler Systems."
   2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

1.8 COORDINATION

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

A. Furnish extra materials 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.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 STEEL PIPE AND FITTINGS

A. Standard Weight, Galvanized- and Black-Steel Pipe: ASTM A 53/A 53M, Type E. Pipe ends may be factory or field formed to match joining method.

B. Schedule 30, Galvanized- and Black-Steel Pipe: ASTM A 135; ASTM A 795/A 795M, Type E; or ASME B36.10M, wrought steel; with wall thickness not less than Schedule 30 and not more than Schedule 40. Pipe ends may be factory or field formed to match joining method.


D. Galvanized and Uncoated, Steel Couplings: ASTM A 865, threaded.

E. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.

F. Malleable- or Ductile-Iron Unions: UL 860.


H. Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.


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, Inc.
b. Tyco Fire & Building Products LP.
c. Victaulic Company.

2. Pressure Rating: 175 psig (1200 kPa).
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.

K. Steel Pressure-Seal Fittings: UL 213, FM-approved, 175-psig (1200-kPa) pressure rating with steel housing, rubber O-rings, and pipe stop; for use with fitting manufacturers' pressure-seal tools.

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

2.3 PIPING JOINING MATERIALS

A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick.
1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.

C. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 TRIM AND DRAIN VALVES

A. General Requirements:
2. Pressure Rating: 175 psig (1200 kPa) minimum.

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. United Brass Works, Inc.
C. Ball Valves:

1. 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. Affiliated Distributors.
   b. Anvil International, Inc.
   c. Barnett.
   d. Conbraco Industries, Inc.; Apollo Valves.
   e. Fire-End & Croker Corporation.
   f. Fire Protection Products, Inc.
   g. Flowserve.
   h. FNW.
   i. Jomar International, Ltd.
   j. Kennedy Valve; a division of McWane, Inc.
   k. Kitz Corporation.
   l. Legend Valve.
   m. Metso Automation USA Inc.
   n. Milwaukee Valve Company.
   o. NIBCO INC.
   p. Potter Roemer.
   q. Red-White Valve Corporation.
   r. Southern Manufacturing Group.
   s. Stewart, M. A. and Sons Ltd.
   t. Tyco Fire & Building Products LP.
   u. Victaulic Company.
   v. Watts Water Technologies, Inc.

D. Globe Valves:

1. 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. Fire Protection Products, Inc.
   b. United Brass Works, Inc.

2.5 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

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

   a. Anvil International, Inc.
   b. National Fittings, Inc.
   c. Shurjoint Piping Products.
   d. Tyco Fire & Building Products LP.
   e. Victaulic Company.
3. Pressure Rating: [175 psig (1200 kPa) minimum] [300 psig (2070 kPa)].
5. Type: Mechanical-T and -cross fittings.
6. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
7. Size: Of dimension to fit onto sprinkler main and with outlet connections as required to match connected branch piping.
8. Branch Outlets: Grooved, plain-end pipe, or threaded.

B. Flow Detection and Test Assemblies:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. AGF Manufacturing Inc.
   b. Reliable Automatic Sprinkler Co., Inc.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with orifice, sight glass, and integral test valve.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

C. 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. AGF Manufacturing Inc.
   b. Triple R Specialty.
   c. Tyco Fire & Building Products LP.
   d. Victaulic Company.
   e. Viking Corporation.
3. Pressure Rating: 175 psig (1200 kPa) minimum.
4. Body Material: Cast- or ductile-iron housing with sight glass.
5. Size: Same as connected piping.
6. Inlet and Outlet: Threaded.

D. Adjustable Drop Nipples:

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. CECA, LLC.  
b. Corcoran Piping System Co.  
c. Merit Manufacturing; a division of Anvil International, Inc.  

3. Pressure Rating: 250 psig (1725 kPa) minimum.  
5. Size: Same as connected piping.  
7. Inlet and Outlet: Threaded.  

E. Flexible, Sprinkler Hose Fittings:  
1. Manufacturers: Subject to compliance with requirements, and approval by local Fire Marshall, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:  
   a. Fivalco Inc.  
   b. FlexHead Industries, Inc.  
   c. Gateway Tubing, Inc.  
3. Type: Flexible hose for connection to sprinkler, and with bracket for connection to ceiling grid.  
4. Pressure Rating: 175 psig (1200 kPa) minimum.  
5. Size: Same as connected piping, for sprinkler.  

2.6 SPRINKLERS  
A. Manufacturers: Subject to compliance with requirements, provide products matching the building standards.  

B. General Requirements:  
2. Pressure Rating for Residential Sprinklers: 175 psig (1200 kPa) maximum.  
3. Pressure Rating for Automatic Sprinklers: 175 psig (1200 kPa) minimum.  

C. Automatic Sprinklers with Heat-Responsive Element:  
2. Nonresidential Applications: UL 199.  
3. Standard response: Standard coverage upright and pendent sprinklers shall be equal to Tyco Model TY-B. Sprinklers shall be of an all brass frame construction with a metal sealing button, coated with Teflon film. Sprinklers shall have a nominal K-factor suited for the application. Sprinklers shall have a standard response glass bulb thermally sensitive operating element. Sprinklers installed in areas without a finished ceiling shall be of a brass finish and shall be of an appropriate temperature classification for the hazard. Sprinklers installed under a finished ceiling shall be a chrome plated pendent style.
sprinkler with an adjustable recessed chrome plated escutcheon. Sprinklers shall be UL listed or FM approved.

4. Quick response: Standard coverage upright, pendent, and recessed. Pendent sprinklers shall be equal to Tyco Model TY-FRB. Sprinklers shall be of an all brass frame construction with a metal sealing button, coated with Teflon film. Sprinklers shall have a nominal K-factor suited for the application. Sprinklers shall have a fast response glass bulb thermally sensitive operating element. Sprinklers installed in areas without a finished ceiling shall be of a brass finish and shall be of an appropriate temperature classification for the hazard. Sprinklers installed under a finished ceiling shall be a chrome plated pendent style sprinkler with an adjustable recessed chrome plated escutcheon. Sprinklers shall be UL listed or FM approved.

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. AMETEK; U.S. Gauge Division.
2. Ashcroft, Inc.
4. WIKA Instrument Corporation.

B. Standard: UL 393.

C. Dial Size: 3-1/2- to 4-1/2-inch (90- to 115-mm) diameter.

D. Pressure Gage Range: 0 to 250 psig (0 to 1725 kPa) minimum.

E. Water System Piping Gage: Include "WATER" or "AIR/WATER" label on dial face.

F. Air System Piping Gage: Include retard feature and "AIR" or "AIR/WATER" label on dial face.

2.8 PIPE ESCUTCHEONS

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One-Piece, Stamped-Steel Escutcheons: Chrome-plated finish with set-screw or spring clips.

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

PART 3 - EXECUTION

3.1 PREPARATION

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

B. Report test results promptly and in writing.
3.2 COORDINATION WITH OTHER TRADES:
   A. Coordinate closely with all other trades to expedite construction and avoid interference.
   B. Special attention shall be paid to locate sprinklers in the studio, control room, and other critical areas.

3.3 PAINTING AND PATCHING:
   A. All sprinkler piping shall be thoroughly cleaned, removing all dirt, oil, etc. and made ready to receive paint in accordance with the General Conditions of the Contract.
   B. Holes in walls or floors cut during the performance of this work shall be patched if the holes cannot be covered by standard escutcheon plates so as to completely conceal the cuts where they would otherwise be exposed to view.
   C. Firestop all penetrations of fire rated assemblies

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

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with requirements for hanger materials in NFPA 13.

M. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

N. Pressurize and check preaction sprinkler system piping and air-pressure maintenance devices.

O. Fill sprinkler system piping with water.

3.5 JOINT CONSTRUCTION

A. Install couplings, flanges, flanged fittings, unions, nipples, and transition and special fittings that have finish and pressure ratings same as or higher than system’s pressure rating for aboveground applications unless otherwise indicated.

B. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller.

C. Install flanges, flange adapters, or couplings for grooved-end piping on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger end connections.

D. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

E. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

F. Flanged Joints: Select appropriate gasket material in size, type, and thickness suitable for water service. Join flanges with gasket and bolts according to ASME B31.9.

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

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

H. Twist-Locked Joints: Insert plain end of steel pipe into plain-end-pipe fitting. Rotate retainer lugs one-quarter turn or tighten retainer pin.

I. Steel-Piping, Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
J. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

1. Shop weld pipe joints where welded piping is indicated. Do not use welded joints for galvanized-steel pipe.

K. Steel-Piping, Cut-Grooved Joints: Cut square-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe joints.

L. Steel-Piping, Roll-Grooved Joints: Roll rounded-edge groove in end of pipe according to AWWA C606. Assemble coupling with housing, gasket, lubricant, and bolts. Join steel pipe and grooved-end fittings according to AWWA C606 for steel-pipe grooved joints.

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

3.6 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire-protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised open, located to control sources of water supply except from fire-department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water-supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.


3. Deluge Valves: Install in vertical position, in proper direction of flow, and in main supply to deluge system. Install trim sets for drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

3.7 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

3.8 ESCUTCHEON INSTALLATION

A. Install escutcheons for penetrations of walls, ceilings, and floors.
B. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece stamped steel with set-screw.
   3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, stamped steel with set-screw.
   4. Bare Piping in Unfinished Service Spaces: One piece, stamped steel with set-screw.
   5. Bare Piping in Equipment Rooms: One piece, stamped steel with set-screw.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

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

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

3.11 CLEANING
A. Clean dirt and debris from sprinklers.
B. Remove and replace sprinklers with paint other than factory finish.
3.12 DEMONSTRATION

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

3.13 PIPING SCHEDULE

A. Piping between Fire-Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

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

C. Standard-pressure, wet-pipe sprinkler system, NPS 2 (DN 50) and smaller, shall be one of the following:
   1. Standard-weight or Schedule 30, black-steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
   2. Standard-weight or Schedule 30, black-steel pipe with cut-grooved or rolled grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

D. Standard-pressure, wet-pipe sprinkler system, NPS 2-1/2 to NPS 4 (DN 65 to DN 100), shall be one of the following:
   1. Standard-weight or Schedule 30, black-steel pipe with cut-grooved or rolled grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

E. Standard-pressure, wet-pipe sprinkler system, NPS 5 (DN 125) and larger, shall be the following:
   1. Standard-weight or Schedule 30, black-steel pipe with cut-grooved or rolled grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end-pipe couplings for steel piping; and grooved joints.

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END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Sleeves.
5. Escutcheons.
7. Equipment installation requirements common to equipment sections.
8. Painting and finishing.
9. Concrete bases.
10. Supports and anchorages.

B. When used in these specifications the term “Provide” is defined to mean “furnish and install” materials, equipment, etc.

C. When noted on the drawings that items (materials, equipment, etc.) are owner furnished, this contractor shall install the item and shall provide all trade materials (pipe, fittings, nuts, bolts, etc.) necessary for a complete and operational system.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlsaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

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

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

B. General: Follow the procedures specified in Division 1.

C. Prior to the performance of any work or installation of any materials, obtain approval from the Engineer by submitting shop drawings and data sheets.

D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the engineer of record will not be processed.

E. Any items with a tag number must be submitted for review. Submittals shall provide all pertinent data and information necessary to evaluate each item. In addition to the requirements outlined in the Division 1 sections and specific Division 22 sections, all submittals must indicate the applicable specification section number and equipment tag number.

F. Engineer’s review of shop drawings does not release Contractor from responsibility of coordinating his work at jobsite and taking field measurements. In cases where interferences become apparent, the Contractor shall notify Engineer so that such interferences may be resolved prior to proceeding with shop work. No claim will be allowed for work that might have to be moved or replaced based on a claim that work was placed in accordance with dimensions shown on an approved shop drawing.

G. Welding certificates.
1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate with the building trades:

1. Structural members, pads, and building openings for mechanical equipment, ducts, piping, fans, etc., are the coordination responsibility of the contractor. Any changes in the above requirements will be paid for by the Contractor.

2. The Drawings show the general arrangement, directions and sizes of Equipment, Piping, etc. It is not intended to show every offset and fitting of every site difficulty that may be encountered, but this Contractor shall furnish and install all materials and perform all labor necessary to make complete working systems, ready for use, without extra charge to the Owner or Engineer. All measurements must be verified on the jobsite.

3. Examine the site and all drawings before proceeding with the layout and installation of this work to suit actual conditions. Confer and cooperate with other trades on the job so that all work will be installed in proper relationship. Precise location of parts to coordinate
with other work is the responsibility of this Contractor. All systems shall be installed to provide maximum headroom, except where dimensioned otherwise on the drawings.

4. Provide full time superintendent who shall oversee and coordinate the work with other trades and the Engineer.

E. Coordinate with electrical work:
1. All motor starters, relays, contactors, etc. supplied as part of packaged equipment shall meet the requirements of the Division 26 Specifications.
2. All other motor starters, relays, contactors, etc. shall be provided under Division 26 specifications or as shown on the electrical drawings.
3. All control wiring for control devices, magnetic coils, damper operators, etc. shall not exceed 120 volts. Where power voltage for equipment is over 120 volts, a transformer shall be provided and wired for the controls.
4. Control wiring to solenoid and control valves, and all other control or controlled devices is to be provided under Division 22, in accordance with the requirements of Division 26, unless otherwise shown on the Electrical Drawings.
5. 120-volt power source for equipment will be made available, under Division 26, at the distribution breaker panels as indicated on the electrical drawings.

1.8 SITE EXAMINATION AND PRE-BID INSPECTION

A. This project consists of the construction of a new communications classroom building to simulate a "real world" newsroom and TV studio. Prior to submitting a bid for the proposed work, contractors shall examine the documents and construction site carefully, noting locations and conditions under which the work will be performed and accepting the responsibility for performing the work under the existing conditions.

B. Submittal of a bid indicates the contractor understands the scope and complexity of the work and accepts the responsibilities for performing the work under the existing conditions in accordance with all applicable codes and regulations, within the allotted schedule.

1.9 CONSTRUCTION PERMITS AND INSPECTIONS

A. Contractor shall file for and obtain all required permits and licenses, and pay all related inspection and permitting fees, as required for the execution of the contract. Arrange for necessary inspections required by City, County, State and other Authorities Having Jurisdiction in a timely manner and as required over the complete course of construction. Deliver inspection certificates and written approval notices to the Owner at contract closeout. Those items and systems deemed critical or required to obtain a completed Certificate of Occupancy shall take priority over non-critical items.

B. Any deficiencies noted by the various inspection departments, by the Engineer, or by Authorities Having Jurisdiction shall be addressed immediately and corrected in a timely fashion in order to avoid a delay in the construction sequence or in obtaining a Certificate of Occupancy.
1.10 WORKMANSHIP AND QUALIFICATIONS

A. All equipment, materials, specialties, etc., shall be installed and connected in accordance with the best engineering practice and standards for this type work. Unless otherwise specified or shown on the Drawings, the recommendations and instructions of the manufacturer shall be followed for installing the work.

B. Contractor shall be experienced and fully licensed to perform construction of the type and class required under this contract.

C. Contractor shall keep a competent superintendent and any necessary assistants satisfactory to the Owner and the Engineer in charge during the progress of the work. Contractor's superintendent shall properly coordinate and time their work with the work of other trades and in particular with roofing and electrical work to avoid errors and delays. Contractor shall pay cost involved due to his failure to comply with these requirements or due to his failure to acquaint himself with the work in progress of the other trades.

D. All workmen shall be skilled in the task assigned them.

E. Work shall be completed in a neat, orderly and professional manner.

F. Should any dispute arise as to the quality or fitness of any material or workmanship, the decision shall rest with the Engineer.

G. Steel Support Welding: Qualify process and operators according to AWS D1.1. "Structural Welding Code – Steel."

H. Steel Pipe Welding: Qualify process and operators according to ASME Boiler and Pressure Vessel Code: Section IX “Welding and Brazing Qualifications.” Comply with provisions in ASME B31 Series. “Code for Pressure Piping.” Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current. All welders employed for this work shall be qualified by the contractor under the qualification procedures specified by the American Welding Societies’ standard D10.9 Level AR-3. Evidence of welder’s qualifications shall be submitted to the Engineer before any welds are made.

1.11 CONSTRUCTION DOCUMENTS.

A. The drawings for plumbing work are in part diagrammatic, intended to convey the scope of work and indicate general arrangement and approximate sizes and locations of equipment and materials. Where job conditions require reasonable changes in indicated locations and arrangement, the contractor shall make such changes as directed by the engineer, without additional cost to the Owner.

B. Because of the scale of the drawings, certain basic items such as pipe fittings, access panels, sleeves, etc. may not be shown; but where such items are required by the nature of the work, they shall be furnished and installed. Rough-in dimensions and locations shall be verified with the supplier of all equipment furnished by other trades, or by the owner, prior to the time of rough-in.
C. Equipment specifications may not deal individually with minute items required such as components, parts, controls, and devices which may be required to meet the equipment warranties. Where such items are required, they shall be included by the supplier of the equipment, whether or not specifically called for.

D. The drawings and the specifications are cooperative and supplementary. It is the intent of both said drawings and specifications to cover all requirements in their entirety as nearly as possible. The contractor shall closely check the drawings and specifications for any obvious errors or omissions and bring any such condition to the attention of the Engineer prior to the receipt of bid, in order to permit clarification by means of a mailed Addendum. If there are no questions prior to the bid proposal date, it shall be understood that the drawings and specifications are complete and correct, and that the intent of said documents will be complied with, and the installation to be complete in all respects, according to said intent. If there is a conflict between the drawings and specifications, the more stringent requirement shall govern, if not clarified in writing by the Engineer.

E. The Contractor shall locate all equipment which must be serviced, operated or maintained in full accessible positions. Minor deviations from the contract drawings may be made to allow for better accessibility, but changes of magnitude, or which involve extra cost, shall not be made without approval. Ample space shall be allowed for removal of all parts that may require replacement or service in the future.

1.12 RECORD DOCUMENTS

A. Record Drawings: Maintain a clean, undamaged set of blue or black line white-prints of Contract Drawings and Shop Drawings as required in Division 1 of these specifications. As the work progresses mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.
   1. Mark new information that is important to the Owner, but was not shown on Contract Drawings or Shop Drawings. Include all change order items, bulletins, addenda, or field changes.
   2. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set. Submit the record drawings as part of the project closeout package.
   3. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 22 Section "Mechanical Identification." Indicate actual inverts and horizontal locations of underground piping.
   4. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
   5. Approved substitutions, contract modifications, and actual equipment and materials installed.
   6. Include all "Corrected For Record" shop drawings to reflect approvals received.

B. Engage the services of a Land Surveyor or Professional Engineer to record the locations and invert elevations of all underground installations.
C. Mark Specifications to indicate approved substitutions and actual equipment and materials used.

1.13 MAINTENANCE MANUALS

A. Organize operating and maintenance data into suitable sets of manageable size, meeting the requirements of Division 1. Bind properly indexed data in individual heavy-duty 2-inch, 3-ring vinyl-covered binders, with pocket folders for folded sheet information. Mark appropriate identification on front and spine of each binder. Include the following types of information:

1. Spare parts list.
2. Copies of warranties.
3. Wiring diagrams.
4. Inspection procedures.
5. Approved Shop Drawings and Product Data.
6. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
7. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
8. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
9. Servicing instructions and lubrication charts and schedules.
10. Provide an index for equipment which shall include the Manufacturer and local representative with address and telephone number.

1.14 WARRANTIES

A. Refer to Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Compile and assemble the warranties of equipment specified in Division 22, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item of product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

D. This contractor shall provide warranty coverage on all materials and equipment installed, including owner furnished equipment, for a period of one (1) year from the date of substantial completion. The warranty shall cover the cost of labor and material for the repair or replacement of any and all defective materials.

1.15 PRODUCT LISTING

A. Prepare listing of major equipment and materials for the project.
B. When two or more items of same material or equipment are required, they shall be by the same manufacturer. Product manufacturer uniformity does not apply as applicable for project to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.

C. Provide products which are compatible with systems and other connected items.

1.16 NAMEPLATE DATA

A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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

2.2 DESIGN BASIS

A. The products/materials specifically named in the specification and/or on the Drawings are the basis of design. The Engineer and/or Owner’s Representative reserves the right to reject product/materials, even if from other acceptable manufacturers, if it is felt they do not meet the intent of the specification.

B. The Engineer reserves the sole right for the approval of proposed material for equipment, and the phrase, "or an approved equivalent", used in these specifications, or on the drawings, shall be interpreted to mean an equivalent approved by the Engineer.

C. All changes required by alternate equipment shall be made at no additional cost to the owner; and all costs incurred by other trades, public utilities or the owner, as a result of the use of such equipment, shall be the responsibility of the contractor.

D. The Contractor shall identify the differences in alternate material or equipment as compared to that specified, and shall indicate the benefits to the project as a result of selecting the alternative.

E. The Engineer reserves the right to refuse approval of equipment which does not meet the specification, in his opinion, or of equipment for which no local experience of satisfactory service
is available. The Engineer further reserves the right to reject equipment for which maintenance service and the availability of replacement parts is questionable.

2.3 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.4 JOINING MATERIALS

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

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.
C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

1. Available Manufacturers:
   a. Capitol Manufacturing Co.
   b. Eclipse, Inc.
   c. Epco Sales, Inc.
   e. Watts Industries, Inc.; Water Products Div.
   f. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

1. Available Manufacturers:
   a. Capitol Manufacturing Co.
   b. Epco Sales, Inc.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Available Manufacturers:
   a. Calpico, Inc.
   b. Lochinvar Corp.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Available Manufacturers:
   a. Perfection Corp.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Co., Inc.
   d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Available Manufacturers:
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
c. Metraflex Co.
d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.
B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.
C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
   1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

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

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:
   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Insulated Piping: One-piece, stamped-steel type with spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with exposed hinge and set screw.

f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated rough-brass finish.

g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.

h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

   a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).

   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

   1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten
bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

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

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."
B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 CONCRETE BASES

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

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use supported equipment manufacturer’s setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Install anchor bolts according to anchor-bolt manufacturer’s written instructions.
7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section “Cast-in-Place Concrete.”

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

3.8 GROUTING

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

END OF SECTION 220500
SECTION 22 05 23

GENERAL DUTY VALVES FOR PLUMBING PIPING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Division-22 section "Basic Mechanical Requirements" applies to work of this section.

1.2 SUMMARY

A. This Section includes general duty valves and strainers common to most plumbing piping systems.
   1. Special purpose valves and strainers are specified in individual piping system specifications.

1.2 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Related Documents Specification Sections.
   1. Product data, including body material, design, pressure and temperature classification, end connection details, seating materials, trim material and arrangement, dimensions and required clearances, and installation instructions.

1.4 QUALITY ASSURANCE

A. Single Source Responsibility: To the fullest extent possible, provide products of the same kind, from a single source.
B. American Society of Mechanical Engineers (ASME) Compliance: Comply with ASME B31.9 for building services piping and ASME B31.1 for power piping.
C. Manufacturers Standardization Society of the Valve and Fittings Industry (MSS) Compliance: Comply with the various MSS Standard Practices referenced.

1.5 DELIVERY, STORAGE, AND HANDLING

A. The following information is paraphrased from the manufacturers standardization society of the valve and fittings industry, inc.
   1. Preparation For Transport: Prepare valves and strainers for shipping as follows:
      2. Ensure valves and strainers are dry and internally protected against rust and corrosion.
      3. Protect ends against damage to threads, flange faces, and weld-end preps.
      4. Set valves and strainers in best position for handling. Set globe and gate valves closed to prevent rattling; set ball and plug valves open to minimize exposure of functional surfaces; set butterfly valves closed or slightly open; and block swing check valves in either closed or open position.
B. Storage: Use the following precautions during storage:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
2. Protect from weather. Store valves and strainers indoors. Maintain valve temperature higher than the ambient dew point temperature. If outdoor storage is necessary, support equipment off the ground or pavement in watertight enclosures.

C. Handling: Use a sling to handle valves or strainers whose size requires handling by crane or lift. Rig valves and strainers to avoid damage to exposed parts. Do not use hand wheels and stems as lifting or rigging points.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide products from one of the manufacturers listed in this specification for each valve type or strainer type, or approved equivalent.

2.2 VALVE FEATURES, GENERAL

A. Valve Design: Rising stem or rising outside screw and yoke stems.

1. Nonrising stem valves may be used where headroom prevents full extension of rising stems.

2. Pressure and Temperature Ratings: As specified and required to suit system pressures and temperatures.

B. Sizes: Same size as upstream pipe, unless otherwise indicated.

C. Operators: Provide the following special operator features:

1. Hand wheels, fastened to valve stem, for valves other than quarter turn.

2. Lever handles, on quarter-turn valves 6-inch and smaller, except for plug valves. Provide plug valves with square heads; provide one wrench for every 10-plug valves.

3. Chain-wheel operators, for valves 2-1/2-inch and larger, installed 72 inches or higher above finished floor elevation. Extend chains to an elevation of 5'-0" above finished floor elevation.

4. Gear drive operators, on quarter-turn valves 8-inch and larger.

D. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

E. Bypass and Drain Connections: Comply with MSS SP-45 bypass and drain connections.

F. End Connections: As indicated in the valve specifications.


(a) Caution: Where soldered end connections are used, use solder having a melting point below 840 deg F for gate, globe, and check valves; below 421 deg F for ball valves.

2.3 GATE VALVES

A. Subject to compliance with the technical requirements, select manufacturer from those listed below, or approved equivalent:

1. Crane

2. Grinnell

3. Hammond

4. Milwaukee

5. Nibco

6. Stockham
B. Service applications for below valve: heating hot water above 200 f, and low-pressure steam.
   Be sure to edit service application specs.

C. GA-1 Gate Valves, 2-Inch and Smaller: MSS SP-80; Class 150, body and union bonnet of
   ASTM B 62 cast bronze; with threaded ends, solid disc, copper-silicon alloy stem, brass pack-
   ing gland, "Teflon" impregnated packing, and malleable iron hand wheel.

D. GA-2 Gate Valves, 2-1/2-Inch and Larger: Flanged, MSS SP-70; Class 125 iron body, bronze
   mounted, with body and bonnet conforming to ASTM A 126 Class B; with flanged ends, "Tef-
   lon" impregnated packing, and two-piece backing gland assembly.

2.4 BALL VALVES

A. Subject to compliance with the technical requirements, select manufacturer from those listed
   below or approved equivalent:
   1. Conbraco (Apollo)
   2. Metraflex
   3. Nibco
   4. Powell
   5. Watts

B. BA-1 Ball Valves, 1 Inch and Smaller: Rated for 150 psi saturated steam pressure, 400 psi
   WOG pressure; two-piece construction; with bronze body conforming to ASTM B 62, standard
   (or regular) port, chrome-plated brass ball, replaceable "Teflon" or "TFE" seats and seals,
   blowout-proof stem, and vinyl-covered steel handle. Provide solder or threaded ends for con-
   denser water, chilled water, and domestic hot and cold water service; threaded ends for heating
   hot water and low-pressure steam.

C. BA-2 Ball Valves, 1-1/4-Inch to 2-Inch: Rated for 150 psi saturated steam pressure, 400 psi
   WOG pressure; with bronze body conforming to ASTM B 62, conventional port, chrome-plated
   brass ball, replaceable "Teflon" or "TFE" seats and seals, blowout-proof stem, and vi-
   nyl-covered steel handle. Provide solder or threaded ends for condenser water, chilled water,
   and domestic hot and cold water service; threaded ends for heating hot water and low-pressure
   steam.

2.5 PLUG VALVES

A. Subject to compliance with the technical requirements, select manufacturer from the following,
   or approved equivalent: Lunkenheimer, Powell, Dezurick, Homestead, Mueller.

B. PL-1 Plug Valves, 2 inches and Smaller: Screwed end plug valve w/ resilient seats and bubble-
   tight shutoff. Valve, where applicable, shall carry a UL listing for shutoff service of natural gas
   and fuel oils. Valve shall be rated for 175psig WOG at temperatures up to 180°F. Valve body
   shall be cast iron ANSI or MSS rated, plug shall be bronze, resilient plug seal shall be Hycar or
   petroleum Hycar as required for service.

C. PL-2 Plug Valves, 2 ½ inches and Larger: Flanged end plug valve w/ resilient seats and bub-
   ble-tight shutoff. Valve, where applicable, shall carry a UL listing for shutoff service of natural
   gas and fuel oils. Valve shall be rated for 175psig WOG at temperatures up to 180°F. Valve
   body shall be cast iron ANSI or MSS rated, plug shall be bronze, resilient plug seal shall be Hy-
   car or petroleum Hycar as required for service.

D. PL-3 Plug Valves, screwed end lubricated plug cock for 1/2psig or less natural gas: UL and
   AGA approved for the service with 150psig WOG brass body, brass plug with square head and
   screwed ends.

2.6 CHECK VALVES

A. Subject to compliance with the technical requirements, select check valve manufacturer from
   those listed below:
   1. Crane
2. Grinnell
3. Hammond
4. For grooved connections, use Victaulic

B. Subject to compliance with the technical requirements, select wafer check valve manufacturer from those listed below:
1. Bell & Gossett
2. Center Line
3. Metraflex
4. Mission
5. Victaulic

C. CK-1 Check Valves, through 2 inch: Rated for 150# steam, 300# WOG. Construction shall be cast-bronze body and cap conforming to ASTM B 62; bronze disc; and having threaded or solder ends.

D. CK-2 Check Valves, 2-1/2-Inch and Larger: MSS SP-71; Class 125 (Class 175 FM approved for fire protection piping systems), cast iron body and bolted cap conforming to ASTM A 126, Class B; horizontal swing, and bronze disc or cast-iron disc with bronze disc ring; and flanged ends. Provide valves capable of being refitted while the valve remains in the line.

E. CK-3 Check Valves, 2 1/2 inch and Larger: 125# flanged end swing check, with lever and weight, rated for 200# WOG. Valve shall be cast iron construction for horizontal or vertical installation, 150 °F maximum temperature, bolted cap, bronze mounted BUNA-N disk.

2.7 STRAINERS

A. Strainer basket shall be of appropriate strainer mesh for the intended service. Basket material shall be stainless steel or monel. Screen hole sizes for typical services shall be as listed below:

<table>
<thead>
<tr>
<th>Service</th>
<th>Hole Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>.034 To .057 inches.</td>
</tr>
<tr>
<td>Gases and air</td>
<td>.006 inches.</td>
</tr>
</tbody>
</table>

B. Manufacturers of Strainers:
2. Hoffman Specialty ITT; Fluid Handling Div.
3. Metraflex Co.
4. Mueller
5. Spirax Sarco.
6. Victaulic Co. of America. (low pressure applications only)
7. Watts Regulator Co.

C. Strainer below for hydronic services.

D. ST-1 Y-Type Strainer, through 2 inch: Rated for 250# steam, constructed of bronze, with a screwed cover.

E. Strainer below for hydronic services.

F. ST-2 Y-Type Strainer, 2 1/2 inch and Larger: Rated for 125# steam, 175# WOG. Construction shall be cast iron, bolted cover.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine valve interior through the end ports 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. Actuate valve through an open-close and close-open cycle. Examine functionally significant features, such as guides and seats made accessible by such actuation. Following examination, return the valve closure member to the shipping position.

C. Examine threads on both the valve and the mating pipe for form (i.e., out-of-round or local indentation) and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Check gasket material for proper size, material composition suitable for service, and freedom from defects and damage.

E. Prior to valve installation, examine the piping for cleanliness, freedom from foreign materials, and proper alignment.

F. Replace defective valves with new valves.

3.2 VALVE ENDS SELECTION

A. Select valves with the following ends or types of pipe/tube connection.
   1. Copper Tube Size, 2-Inch and Smaller: Solder ends, except provide threaded ends for heating hot water and low-pressure steam service.
   2. Steel Pipe Sizes, 2-Inch and Smaller: threaded or grooved end.
   3. Steel Pipe Sizes 2-1/2 Inch and Larger: grooved end or flanged.

3.3 VALVE INSTALLATIONS

A. General Application: Use gate, ball, and butterfly valves for shut-off duty; globe, ball, and butterfly for throttling duty. Refer to piping system specification sections for specific valve applications and arrangements.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves and unions for each fixture and item of equipment arranged to allow equipment removal without system shutdown. Unions are not required on flanged devices.

D. Install three-valve bypass around each pressure-reducing valve using throttling-type valves.

E. Install valves in horizontal piping with stem at or above the center of the pipe.

F. Install valves in a position to allow full stem movement.

3.4 SOLDER CONNECTIONS

A. Solder connections made with 50-50 solder have a maximum operating pressure rating for 1-1/4 to 2 inch sizes, of 175 psi at 100 deg f, decreasing with higher temperatures to 75 psi at 250 deg f. Therefore soldered joints may not meet system pressures.

B. Cut tube square and to exact lengths.

C. Clean end of tube to depth of valve socket with steel wool, sand cloth, or a steel wire brush to a bright finish. Clean valve socket in same manner.

D. Apply proper soldering flux in an even coat to inside of valve socket and outside of tube.

E. Open gate and globe valves to full open position.

F. Remove the cap and disc holder of swing check valves having composition discs.

G. Insert tube into valve socket, making sure the end rests against the shoulder inside valve. Rotate tube or valve slightly to ensure even distribution of the flux.

H. Apply heat evenly to outside of valve around joint until solder will melt upon contact. Feed solder until it completely fills the joint around tube. Avoid hot spots or overheating valve. Once the solder starts cooling, remove excess amounts around the joint with a cloth or brush.

3.5 THREADED CONNECTIONS

A. Note the 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.

B. Align threads at point of assembly.
C. Apply appropriate tape or thread compound to the external pipe threads (except where dry seal threading is specified).
D. Assemble joint, wrench tight. Wrench on valve shall be on the valve end into which the pipe is being threaded.

3.6 FLANGED CONNECTIONS
A. Align flange surfaces parallel.
B. 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.
C. For dead-end service, butterfly valves require flanges both upstream and downstream for proper shutoff and retention.

3.7 FIELD QUALITY CONTROL
A. Tests: After piping systems have been tested and put into service, but before final adjusting and balancing, inspect valves for leaks. Adjust or replace packing to stop leaks; replace valves if leak persists.

3.8 ADJUSTING AND CLEANING
A. Cleaning: Clean mill scale, grease, and protective coatings from exterior of valves and prepare valves to receive finish painting or insulation.

3.9 VALVE APPLICATION SCHEDULE
A. Select valves according to the following schedule:

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>GATE</th>
<th>GLOBE</th>
<th>BALL</th>
<th>CHECK</th>
<th>PLUG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Hot &amp; Cold Water</td>
<td>GA-1</td>
<td>GL-1</td>
<td>BL-1</td>
<td>CK-1</td>
<td>---</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>GA-1</td>
<td>---</td>
<td>BL-1</td>
<td>---</td>
<td>PL-1 or PL-3</td>
</tr>
</tbody>
</table>

C. Valves 2-1/2 inches and Larger:

<table>
<thead>
<tr>
<th>SERVICE</th>
<th>GATE</th>
<th>GLOBE</th>
<th>B'FLY</th>
<th>CHECK</th>
<th>PLUG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic Hot &amp; Cold Water</td>
<td>GA-2</td>
<td>GL-2</td>
<td>BF-1</td>
<td>CK-2</td>
<td>CK-3</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>GA-2</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>PL-2</td>
</tr>
</tbody>
</table>

END OF SECTION 22 05 23
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

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

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
3. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

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

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe stands. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.3, "Structural Welding Code--Sheet Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers:
   2. Carpenter & Paterson, Inc.
   3. Empire Industries, Inc.
4. ERICO/Michigan Hanger Co.
5. Globe Pipe Hanger Products, Inc.
6. Grinnell Corp.
7. GS Metals Corp.
9. PHD Manufacturing, Inc.
10. PHS Industries, Inc.
11. Piping Technology & Products, Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

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

2.4 METAL FRAMING SYSTEMS
A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS
A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Available Manufacturers:
1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

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 (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.6 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.

1. Available Manufacturers:
   a. Hilti, Inc.
   b. ITW Ramset/Red Head.
   c. Masterset Fastening Systems, Inc.
   d. MKT Fastening, LLC.
   e. Powers Fasteners.

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

1. Available Manufacturers:
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
   e. MKT Fastening, LLC.
   f. Powers Fasteners.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

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

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

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. 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 60.
2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 4 requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 4, if little or no insulation is required.
4. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN 20 to DN 200).
5. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN 10 to DN 200).

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 6.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 6 if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
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 (49 to 232 deg C) piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb (340 kg).
   b. Medium (MSS Type 32): 1500 lb (680 kg).
   c. Heavy (MSS Type 33): 3000 lb (1360 kg).
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. 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.

K. 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 (32 mm).
3. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Install hangers and supports complete with necessary 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 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so 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 so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:
   1. Attach clamps and spacers to piping.
      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
      b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
      c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
   2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
   3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
      a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
   4. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
      b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
      c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
      d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
   5. Pipes NPS 8 (DN 200) and Larger: Include wood inserts.
   6. Insert Material: Length at least as long as protective shield.
   7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

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

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

3.4 METAL FABRICATIONS

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

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

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

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touch Up: 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.

END OF SECTION 22 05 29
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.
   B. Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

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 (0.8-mm) minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).
3. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel [rivets] [rivets or self-tapping screws] [self-tapping screws].
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

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

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

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch (1.6 mm) thick, and having predrilled holes for attachment hardware.


C. Background Color: Red.
D. Maximum Temperature: Able to withstand temperatures up to 160 deg F (71 deg C).

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch (64 by 19 mm).

F. Minimum Letter Size: 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), 1/2 inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets.

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. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

   1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   2. Lettering Size: At least 1-1/2 inches (38 mm) high.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.

   2. Stencil Paint: Exterior, gloss, alkyd enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, alkyd 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 (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.

   1. Tag Material: Brass, 0.032-inch (0.8-mm) 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 (A4) 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 (75 by 133 mm) minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.

3.3 PIPE LABEL INSTALLATION

A. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer’s option. Install stenciled pipe labels with painted, color-coded bands or rectangles complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.

B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. At access doors, manholes, and similar access points that permit view of concealed piping.
5. Near major equipment items and other points of origination and termination.
6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and 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 complying with ANSI A13.1.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION 220553
SECTION 22 07 00
PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1 Specification Sections, and all other Division 22 sections apply to work of this section.

1.2 SUMMARY
A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.
B. Types of mechanical insulation specified in this section include the following:
   1. Piping System Insulation:
      a. Fiberglass.
      b. Flexible Unicellular.
C. Refer to Division-22 section "Hangers and Supports for Plumbing Piping and Equipment" for protection saddles, protection shields, and thermal hanger shields; not work of this section.
D. Refer to Division-22 section "Identification for Plumbing Piping and Equipment" for installation of identification devices for plumbing piping and equipment; not work of this section.

1.3 QUALITY ASSURANCE
A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.
B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.
   1. Exception: Outdoor mechanical insulation may have flame-spread index of 75 and smoke developed index of 150.
C. Plenum Ratings: Provide product approved for installation in air plenums where applicable.

1.4 DELIVERY, STORAGE, AND HANDLING
A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.
B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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

1. Armstrong World Industries, Inc.
2. CertainTeed Corp.
3. Knauf Fiber Glass GmbH.
4. Owens-Corning Fiberglas Corp.

2.2 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C 547; 'k' value of 0.24 at 75 degrees F; noncombustible.

B. Flexible Unicellular Piping Insulation: ASTM C 534; flexible, elastomeric; 'k' value of 0.27 at 75 degrees F., water vapor permeability = 0.1 perm, density 4.5 lb/FT^3.

C. Jackets for Piping Insulation: ASTM C 921, Type I (vapor barrier) for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.

1. Encase pipefittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
2. Encase exterior piping insulation with aluminum jacket with weather-proof construction.
3. Exterior piping jacket shall be Aluminum alloy 5005-H16 with smooth finish. Thickness shall be 0.016 inch for 12.75 inch O.D. and smaller and have factory applied vapor barrier liner.

D. Staples, Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated. Use stainless steel staples if required for piping below ambient temperature.

E. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PIPING SYSTEM INSULATION, GENERAL

A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, strainers, check valves, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, buried piping, fire protection piping, and pre-insulated equipment.

B. The installed R-value of all pipe insulation shall be in accordance with the requirements of the 2012 International Energy Conservation Code (IECC).
3.3 PIPE INSULATION APPLICATION SCHEDULE

A. Insulate piping according to the following insulation application schedule:

<table>
<thead>
<tr>
<th>TEMP RANGE</th>
<th>SERVICE</th>
<th>INSUL TYPE</th>
<th>PIPE SIZE</th>
<th>INSUL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>-Domestic Cold and Hot Water, above ground</td>
<td>FG</td>
<td>1&quot; &amp; less</td>
<td>1&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 ½&quot; – 2&quot;</td>
<td>1 ½&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 ½&quot; &amp; above</td>
<td>2&quot;</td>
</tr>
<tr>
<td>40°F to Ambient</td>
<td>-Air Conditioning Condensate Drain</td>
<td>FG</td>
<td>4&quot; &amp; less</td>
<td>1&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UC</td>
<td>1&quot; &amp; less</td>
<td>¾&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over 1&quot;</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>

3.4 INSULATION OF PIPING EXPOSED TO WEATHER

A. Protect outdoor insulation from weather by installing aluminum outdoor protective finish or jacketing with installation as recommended by the manufacturer.

3.5 INSTALLATION OF PIPING INSULATION

A. General: Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

G. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

H. Piping Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by manufacturer.

I. Protect outside unicellular insulation with two coats of finish over glass mesh, which has been adhered to the insulation with adhesive.

J. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3" wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap

3.6 PROTECTION AND REPLACEMENT

A. Replace damaged insulation, which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture-saturated units.
B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 22 07 00
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. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Encasement for piping.
4. Flexible connectors.
5. Water meters furnished by utility company for installation by Contractor.
7. Escutcheons.
8. Sleeves and sleeve seals.
9. Wall penetration systems.

B. Related Section:

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

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to ASCE/SEI 7.

1.4 SUBMITTALS

A. Product Data: For the following products:

1. Specialty valves.
2. Transition fittings.
3. Dielectric fittings.
4. Flexible connectors.
5. Backflow preventers and vacuum breakers.
7. Sleeves and sleeve seals.

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.

D. Field quality-control reports.

1.5 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.

1.6 COORDINATION

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

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.

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) and ASTM B 88, Type M (ASTM B 88M, Type C) water tube, drawn temper.

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.
5. Copper Pressure-Seal-Joint 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) Elkhart Products Corporation; Industrial Division.
      2) NIBCO INC.
      3) Viega; Plumbing and Heating Systems.
b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.

c. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

6. Copper Push-on-Joint 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) NVent LLC.

b. Description: Cast-copper fitting complying with ASME B16.18 or wrought-copper fitting complying with ASME B 16.22; with stainless-steel teeth and EPDM-rubber O-ring seal in each end instead of solder-joint ends.

7. Copper-Tube Extruded-Tee Connections:

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) T-DRILL Industries Inc.

b. Description: Tee formed in copper tube according to ASTM F 2014.

B. Soft Copper Tube: ASTM B 88, Type K (ASTM B 88M, Type A) and ASTM B 88, Type L (ASTM B 88M, Type B) water tube, annealed temper.


2. Copper Pressure-Seal-Joint Fittings:

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

1) Elkhart Products Corporation; Industrial Division.
2) NIBCO INC.
3) Viega; Plumbing and Heating Systems.

b. NPS 2 (DN 50) and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.

c. NPS 3 and NPS 4 (DN 80 and DN 100): Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

2.3 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.
2.4 TRANSITION FITTINGS

A. General Requirements:

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

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

C. Sleeve-Type Transition Coupling: AWWA C219.

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. Cascade Waterworks Manufacturing.
   b. Dresser, Inc.; Dresser Piping Specialties.
   c. Ford Meter Box Company, Inc. (The).
   d. JCM Industries.
   e. Romac Industries, Inc.
   f. Smith-Blair, Inc; a Sensus company.
   g. Viking Johnson; c/o Mueller Co.

2.5 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:
   b. Central Plastics Company.
   c. EPCO Sales, Inc.
   d. Hart Industries International, Inc.
   e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   f. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:
   a. Pressure Rating: 150 psig (1035 kPa).
   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:
   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 (1035 kPa).
   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 (1035 kPa).
   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 (2070 kPa) at 225 deg F (107 deg C).
   c. End Connections: Female threaded.
   d. Lining: Inert and noncorrosive, thermoplastic.
F. Dielectric 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. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Victaulic Company.

2. Description:
   a. Electroplated steel nipple complying with ASTM F 1545.
   b. Pressure Rating: 300 psig (2070 kPa) at 225 deg F (107 deg C).
   c. End Connections: Male threaded or grooved.
   d. Lining: Inert and noncorrosive, propylene.

2.6 FLEXIBLE CONNECTORS

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

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Flex Pression, Ltd.
4. Flex-Weld, Inc.
5. Hyspan Precision Products, Inc.
7. Metraflex, Inc.
8. Proco Products, Inc.
10. Unaflex, Inc.
11. Universal Metal Hose; a Hyspan company

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 (1380 kPa).
2. End Connections NPS 2 (DN 50) and Smaller: Threaded copper pipe or plain-end copper tube.
3. End Connections NPS 2-1/2 (DN 65) and Larger: Flanged copper alloy.

C. Stainless-Steel-Hose Flexible Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

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

A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.

B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.


D. One Piece, Stamped Steel: Chrome-plated finish with setscrew.

E. Split Casting, Cast Brass: Polished, chrome-plated finish with concealed hinge and setscrew.

F. Split Plate, Stamped Steel: Chrome-plated finish with concealed hinge, setscrew.

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

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

2.8 SLEEVES

A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

C. Molded-PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

D. Molded-PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

E. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.

F. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.

G. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.9 SLEEVE SEALS

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

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.
B. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel.
3. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.10 WALL PENETRATION 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. SIGMA.

B. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.

1. Carrier-Pipe Deflection: Up to 5 percent without leakage.
2. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
3. Housing-to-Sleeve Gasket: EPDM rubber.

2.11 GROUT


B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000 psi (34.5 MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. Indicated locations and arrangements are used to size pipe and
calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install underground copper tube in PE encasement according to ASTM A 674 or AWWA C105.

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

F. Install shutoff valve immediately upstream of each dielectric fitting.

G. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

H. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.

I. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

J. Install seismic restraints on piping. Comply with requirements in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for seismic-restraint devices.

K. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

L. 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.

M. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

N. Install piping adjacent to equipment and specialties to allow service and maintenance.

O. Install piping to permit valve servicing.

P. 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.

Q. Install piping free of sags and bends.

R. Install fittings for changes in direction and branch connections.

S. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
T. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

U. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

V. Install thermometers on inlet and outlet piping from water heater, WH-5. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

3.3 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
   1. Apply appropriate tape or thread compound to external pipe threads.
   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: 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. Pressure-Sealed Joints: Join copper tube and pressure-seal fittings with tools recommended by fitting manufacturer.

G. Copper-Tubing, Push-on Joints: Clean end of tube. Measure insertion depth with manufacturer's depth gage. Join copper tube and push-on-joint fittings by inserting tube to measured depth.

H. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

I. 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.

J. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.
3.4 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 (DN 50) and smaller.

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.

D. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

3.5 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. NPS 1-1/2 (DN 40) and Smaller: Fitting-type coupling.
2. NPS 2 (DN 50) and Larger: Sleeve-type coupling.

3.6 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 (DN 50) and Smaller: Use dielectric unions.

3.7 FLEXIBLE CONNECTOR INSTALLATION

A. Install bronze-hose flexible connectors in copper domestic water tubing.

B. Install stainless-steel-hose flexible connectors in steel domestic water piping.

3.8 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 (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m) If Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.
C. Support vertical piping and tubing at base and at each floor.
D. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch (10 mm).
E. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
F. Install supports for vertical copper tubing every 10 feet (3 m).
G. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
   4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
   5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
   6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
H. Install supports for vertical steel piping every 15 feet (4.5 m).

3.9 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. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
2. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.

3. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection.

3.10 ESCUTCHEON INSTALLATION

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

B. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
   2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish.
   4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with rough-brass finish.
   5. Bare Piping in Equipment Rooms: One piece, cast brass.
   6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.11 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

B. Sleeves are not required for core-drilled holes.

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:
1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
   a. Extend sleeves 2 inches (50 mm) above finished floor level.
   b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
3. Sleeves for Piping Passing through Gypsum-Board Partitions:
   a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
   b. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
5. Sleeves for Piping Passing through Exterior Concrete Walls:
   a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
   b. Install sleeves that are large enough to provide 1-inch (25-mm) annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
   c. Do not use sleeves when wall penetration systems are used.
6. Sleeves for Piping Passing through Interior Concrete Walls:
   a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).

L. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.12 SLEEVE SEAL INSTALLATION
A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.13 WALL PENETRATION SYSTEM INSTALLATION
A. Install wall penetration systems in new, exterior concrete walls.
B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.
3.14 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.

3.15 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 (345 kPa) 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.
3.16 ADJUSTING

A. Perform the following adjustments before operation:

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

3.17 CLEANING

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

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

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

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

C. Prepare and submit reports of purging and disinfecting activities.

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

3.18 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 (DN 80) and smaller, shall be the following:
   1. Soft copper tube, ASTM B 88, Type K (ASTM B 88M, Type A)

E. Aboveground domestic water piping, [NPS 2 (DN 50) and smaller, shall be one of the following:
   1. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B); cast-copper solder-joint fittings; and brazed joints.
   2. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B) copper pressure-seal-joint fittings; and pressure-sealed joints.
   3. Hard copper tube, ASTM B 88, Type L (ASTM B 88M, Type B) copper push-on-joint fittings; and push-on joints.

3.19 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 (DN 50) and smaller.
   2. Throttling Duty: Use ball or globe valves for piping NPS 2 (DN 50) and smaller.

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 22 11 16
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. Balancing valves.
3. Temperature-actuated water mixing valves.
4. Strainers.
5. Drain valves.
7. Air vents.
8. Trap-seal primer systems.

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" for water meters.
3. Division 22 Section "Emergency Plumbing Fixtures" for water tempering equipment.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.
B. Shop Drawings: Diagram power, signal, and control wiring.
C. Field quality-control test reports.
D. 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 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 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. Ames Co.
   b. Cash Acme.
   c. Conbraco Industries, Inc.
   d. FEBCO; SPX Valves & Controls.
   e. Rain Bird Corporation.
   f. Toro Company (The); Irrigation Div.
   g. Watts Industries, Inc.; Water Products Div.
   h. Zurn Plumbing Products Group; Wilkins Div.

3. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
5. Inlet and Outlet Connections: Threaded.

2.2 BALANCING VALVES

A. Copper-Alloy Calibrated 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:

   b. Flo Fab Inc.
   c. ITT Industries; Bell & Gossett Div.
   d. NIBCO INC.
   e. TAC Americas.
   f. Taco, Inc.
   g. Watts Industries, Inc.; Water Products Div.
2. Type: Y-pattern globe valve with two readout ports and memory setting indicator.
3. Body: Brass or bronze.
4. Size: Same as connected piping, but not larger than NPS 2 (DN 50).
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. 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; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Div.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Red-White Valve Corp.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
4. Size: NPS 2 (DN 50) 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.

2.3 TEMPERATURE-ACTUATED WATER MIXING VALVES

A. Water-Temperature Limiting Devices:

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:
   b. Cash Acme.
   c. Conbraco Industries, Inc.
   d. Honeywell Water Controls.
   e. Legend Valve.
   f. Leonard Valve Company.
   g. Powers; a Watts Industries Co.
   h. Symmons Industries, Inc.
   i. Taco, Inc.
   k. Zurn Plumbing Products Group; Wilkins Div.
4. Type: Thermostatically controlled water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 80° F (deg C).
10. Valve Finish: Rough bronze.

B. Icemaker Outlet Boxes:

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:
   b. IPS Corporation.
   c. LSP Products Group, Inc.
   d. Oatey.
   e. Plastic Oddities; a division of Diverse Corporate Technologies.
4. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 (DN 15) or smaller copper tube outlet.
5. Supply Shutoff Fitting: NPS 1/2 (DN 15) gate, globe, or ball valve and NPS 1/2 (DN 15) copper, water tubing.

2.4 DRAIN VALVES

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

2. Pressure Rating: 400-psig (2760-kPa) minimum CWP.
4. Body: Copper alloy.
5. Ball: Chrome-plated brass.
8. Inlet: Threaded or solder joint.

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

2. Pressure Rating: Class 125.
5. Inlet: NPS 3/4 (DN 20) threaded or solder joint.
6. Outlet: Garden-hose thread complying with ASME B1.20.7 and cap with brass chain.

C. 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 (1380-kPa) minimum CWP or Class 125.
5. Drain: NPS 1/8 (DN 6) side outlet with cap.

2.5 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

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. AMTROL, Inc.
   b. Josam Company.
   c. MIFAB, Inc.
   d. PPP Inc.
   e. Sioux Chief Manufacturing Company, Inc.
   g. Tyler Pipe; Wade Div.
   h. Watts Drainage Products Inc.
   i. Zurn Plumbing Products Group; Specification Drainage Operation.

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

2.6 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer 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:

3. Pressure Rating: 125 psig (860 kPa) minimum.
5. Inlet and Outlet Connections: Same size as floor drain outlet.

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 water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gages on inlet and outlet.

C. Install water control valves with inlet and outlet shutoff valves. Install pressure gages on inlet and outlet.

D. Install balancing valves in locations where they can easily be adjusted.

E. 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.
   2. Install cabinet-type units recessed in or surface mounted on wall as specified.

F. Install Y-pattern strainers for water on supply side of each control valve.

G. Install outlet boxes recessed in wall. Install 2-by-4-inch (38-by-89-mm) fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

H. Install water hammer arresters in water piping according to PDI-WH 201.

I. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

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. Primary, thermostatic, water mixing valves.
   3. Primary water tempering valves.

B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."
3.4 ADJUSTING

A. Set field-adjustable flow set points of balancing valves.

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

END OF SECTION 22 11 19
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. This Section includes the following for soil, waste, and vent piping inside the building:
   1. Pipe, tube, and fittings.
   2. Special pipe fittings.
   3. Encasement for underground metal piping.

1.3 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:
   1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.

C. Field quality-control inspection and test reports.
1.6 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 PIPING MATERIALS

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

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

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Standard, Shielded, Stainless-Steel Couplings: CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve.
a. Manufacturers:

1) ANACO.
2) Fernco, Inc.
3) Ideal Div.; Stant Corp.
4) Mission Rubber Co.
5) Tyler Pipe; Soil Pipe Div.


a. Manufacturers:

1) ANACO.
2) Clamp-All Corp.
3) Ideal Div.; Stant Corp.
4) Mission Rubber Co.
5) Tyler Pipe; Soil Pipe Div.

3. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.

a. Manufacturers:

1) MG Piping Products Co.

C. Rigid, Unshielded Couplings: ASTM C 1461, sleeve-type, reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

a. ANACO.

2.5 COPPER TUBE AND FITTINGS

A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.


B. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.

2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. 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.

C. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.

2.6 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain and waste, below slab installation only.
   1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

B. Cellular-Core PVC Pipe: ASTM F 891, Schedule 40.
   1. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Cellular-Core, Sewer and Drain Series, PVC Pipe: ASTM F 891, Series PS 100.
   1. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Series PS 100 sewer and drain pipe.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section “Earth Moving” for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil and waste piping NPS 4 (DN 100) 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 shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Copper DWV tube, copper drainage fittings, and soldered joints.
   4. Dissimilar Pipe-Material Couplings: Rigid, unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, vent piping NPS 4 (DN 100) 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; standard, shielded, stainless-steel couplings; and hubless-coupling joints.
   3. Copper DWV tube, copper drainage fittings, and soldered joints.
      a. Option for Vent Piping, NPS 2-1/2 and NPS 3-1/2 (DN 65 and DN 90): Hard copper tube, Type M (Type C); copper pressure fittings; and soldered joints.
4. Dissimilar Pipe-Material Couplings: Rigid, unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Underground, soil, waste, and vent piping NPS 4 (DN 100) and smaller shall be any of the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed or calking materials; and calked joints.
2. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
3. Cellular-core, Sewer and Drain Series, PVC pipe; PVC socket fittings; and solvent-cemented joints.
4. Dissimilar Pipe-Material Couplings: Rigid, unshielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 33 Section "Utility Services."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

F. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.


1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

H. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

I. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants.
cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

J. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

K. Install engineered soil and waste drainage and vent piping systems as follows:

2. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

L. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

M. Install PVC soil and waste drainage piping according to ASTM D 2665.

N. Install underground PVC soil and waste drainage piping according to ASTM D 2321.

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

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."


C. Join hub-and-spigot, cast-iron soil piping with caked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum caked joints.

D. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

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

F. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

G. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:
   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.
3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
   2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
   3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
   2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
   3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
   4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.

I. Install supports for vertical copper tubing every 10 feet (3 m).

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.
3.6 CONNECTIONS

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

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

C. Connect drainage and vent piping to the following:
   1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
   2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
   3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
   4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

3.7 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. Openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
   4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in
trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

3.8 CLEANING

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

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

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 22 13 16
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. Cleanouts.
   2. Floor drains.
   3. Roof flashing assemblies.
   4. Through-penetration firestop assemblies.
   5. Miscellaneous sanitary drainage piping specialties.
   6. Flashing materials.
B. Related Sections include the following:
   1. Division 22 Section "Plumbing Fixtures" for hair interceptors.

1.3 DEFINITIONS
A. PVC: Polyvinyl chloride plastic.

1.4 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.

1.5 COORDINATION
A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Exposed Metal Cleanouts:

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:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.
   g. Josam Company; Blucher-Josam Div.

2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
5. Closure: Countersunk plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

B. Metal Floor Cleanouts:

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:
   b. Oatey.
   c. Sioux Chief Manufacturing Company, Inc.
   e. Tyler Pipe; Wade Div.
   f. Watts Drainage Products Inc.
   g. Zurn Plumbing Products Group; Specification Drainage Operation.
   h. Josam Company; Josam Div.
   i. Kusel Equipment Co.

2. Standard: ASME A112.36.2M for cast-iron soil pipe with cast-iron ferrule cleanout.
3. Size: Same as connected branch.
4. Type: Cast-iron soil pipe with cast-iron ferrule.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Not required.
7. Outlet Connection: Threaded.
8. Closure: Brass plug with straight threads and gasket.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Heavy Duty.
13. Riser: ASTM A 74, Service class, cast-iron drainage pipe fitting and riser to cleanout.
15. Size: Same as connected branch.
17. Closure: Stainless steel with seal.
18. Riser: Stainless-steel drainage pipe fitting to cleanout.

C. Cast-Iron Wall Cleanouts:

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:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   b. MIFAB, Inc.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.

4. Standard: ASME A112.36.2M. Include wall access.
5. Size: Same as connected drainage piping.
6. Body: Hubless, cast-iron soil pipe test tee as required to match connected piping.
7. Closure: Countersunk or raised-head plug.
8. Closure Plug Size: Same as or not more than one size smaller than cleanout size.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

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. Commercial Enameling Co.
   b. Josam Company; Josam Div.
   c. MIFAB, Inc.
   d. Prier Products, Inc.
   e. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
   f. Tyler Pipe; Wade Div.
   g. Watts Drainage Products Inc.
   h. Zurn Plumbing Products Group; Light Commercial Operation.
   i. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3.
5. Seepage Flange: Required.
6. Anchor Flange: Required.
7. Clamping Device: Required.
8. Outlet: Bottom.
10. Sediment Bucket: Not required.
11. Top or Strainer Material: Bronze.
13. Top Shape: Round.
14. Dimensions of Top or Strainer: Refer to drawings for size.
15. Top Loading Classification: Heavy Duty.
18. Trap Features: Trap-seal.

2.3 ROOF FLASHING ASSEMBLIES

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 6.0-lb/sq. ft. (30-kg/sq. m), 0.0938-inch- (2.4-mm-) thick, lead flashing collar and skirt extending at least 8 inches (200 mm) from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.

2.4 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop 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. 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.

6. Special Coating: Corrosion resistant on interior of fittings.

2.5 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 (DN 50): 4-inch- (100-mm-) minimum water seal.

   b. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) 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 (DN 15) 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 [1 inch (25 mm)] [2 inches (51 mm)] <Insert dimension> 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: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.

2. Size: Same as connected stack vent or vent stack.
G. 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 (25-mm) enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

H. Expansion Joints:
   1. Standard: ASME A112.21.2M.
   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.

2.6 FLASHING MATERIALS
   A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
      1. General Use: 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.
      2. Vent Pipe Flashing: 3.0-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.
      3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.
   B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:
      1. General Applications: 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).
      2. Vent Pipe Flashing: 8 oz./sq. ft. (2.5 kg/sq. m or 0.27-mm thickness).
   C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness, unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.
   D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.
   E. Fasteners: Metal compatible with material and substrate being fastened.
   F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
   G. Solder: ASTM B 32, lead-free alloy.
   H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION
   A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet (15 m) for piping NPS 4 (DN 100) and smaller and 100 feet (30 m) for larger piping.
4. Locate at base of each vertical soil and waste stack.

C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
   a. Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.
   b. Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.
   c. Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.
3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

H. Install through-penetration firestop assemblies in plastic stacks at floor penetrations.

I. Assemble open drain fittings and install with top of hub 1 inch (25 mm) above floor.

J. Install deep-seal traps on floor drains and other waste outlets, if indicated.

K. 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.

L. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
M. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

N. Install vent caps on each vent pipe passing through roof, if required by code.

O. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

P. Install wood-blocking reinforcement for wall-mounting-type specialties.

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

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

3.2 CONNECTIONS

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

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

C. 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. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness or thinner.
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 (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.
E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according 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 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.

3.5 PROTECTION

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

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

END OF SECTION 22 13 19
SECTION 22 33 00

ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following electric water heaters:

1. Light-commercial electric water heaters.
2. Compression tanks.
3. Water heater accessories.

1.3 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

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

C. Product Certificates: For each type of commercial and instantaneous electric water heater, signed by product manufacturer.

D. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For electric water heaters to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.

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

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.


E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

1.5 COORDINATION

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

1.6 WARRANTY

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

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.

b. Faulty operation of controls.

c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period(s): From date of Substantial Completion:


b. Light-Commercial Electric Water Heaters:

1) Storage Tank: Five years.
PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 LIGHT-COMMERCIAL ELECTRIC WATER HEATERS

A. Description: Comply with UL 174 for household, storage electric water heaters.

1. Manufacturers:

   c. State Industries, Inc.

2. Storage-Tank Construction: Steel, vertical arrangement.

   b. Pressure Rating: 150 psig (1035 kPa).
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

   a. Anode Rod: Replaceable magnesium.
   b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.
   c. Drain Valve: ASSE 1005.
   e. Jacket: Steel with enameled finish.
   f. Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet.
   g. Heating Elements: Two; electric, screw-in immersion type; wired for simultaneous operation, unless otherwise indicated.
   h. Temperature Control: Adjustable thermostat for each element.
   i. Safety Control: High-temperature-limit cutoff device or system.
   j. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
4. Capacity and Characteristics:
   a. Capacity: Refer to floor plans for this information.
   b. Recovery: Refer to floor plans for this information.
   c. Heating Elements: Refer to floor plans for this information.
   d. Temperature Setting: Refer to floor plans for this information.
   e. Electrical Characteristics:
      1) Power Demand: Refer to floor plans for this information.
      2) Volts: Refer to floor plans for this information.
      3) Phases: Refer to floor plans for this information.
      4) Hertz: 60.
      5) Full-Load Amperes: Refer to floor plans for this information.
      6) Minimum Circuit Ampacity: Refer to floor plans for this information.
      7) Maximum Overcurrent Protection: Refer to floor plans for this information.

2.3 COMPRESSION TANKS

A. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

1. Manufacturers:
   a. AMTROL Inc.
   b. Armstrong Pumps, Inc.
   c. Myers, F. E.; Pentair Pump Group (The).
   d. State Industries, Inc.
   e. Taco, Inc.
   f. Watts Regulator Co.
   g. Wessels Co.

2. Construction:
   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:
   a. Working-Pressure Rating: 150 psig (1035 kPa).
   b. Capacity Acceptable: 4 gal. (15.1 L) minimum.
   c. Air Precharge Pressure: Per manufacture recommendations.

2.4 WATER HEATER ACCESSORIES

A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.

C. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 18-inch- (457-mm-) high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 (DN 25) drain outlet with ASME B1.20.1 pipe thread.

D. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Include dimension that will support bottom of water heater a minimum of 18 inches (457 mm) above the floor.

E. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

F. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).

G. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that are capable of isolating each water heater and of providing balanced flow through each water heater.

H. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1-2004.

I. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig- (172.5-kPa-) maximum outlet pressure, unless otherwise indicated.

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

2.5 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

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

C. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.

1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
2. Concrete base construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer’s recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install seismic restraints for water heaters. Anchor to substrate.

D. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

F. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.

G. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

H. Install thermometers on inlet and outlet piping of household, collector-to-tank, solar-electric water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

I. Install pressure gage(s) on inlet and outlet of commercial electric water-heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

J. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

K. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.

L. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

M. Fill water heaters with water.

N. Charge compression tanks with air.
3.2 CONNECTIONS

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

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

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."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

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

END OF SECTION 22 33 00
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. Laminar-flow faucet-spout outlets.
   3. Flushometers.
   4. Toilet seats.
   5. Fixture supports.
   7. Urinals.
   8. Lavatories.
  10. Service sinks.

B. Related Sections include the following:

   1. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

A. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Fitting: Device that controls the flow of water into or out of the plumbing fixture. 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.

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.


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.
3. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.
5. Vitreous-China Fixtures: ASME A112.19.2M.
H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:

1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
2. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
5. Hose-Connection Vacuum Breakers: ASSE 1011.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

2. Brass and Copper Supplies: ASME A112.18.1.

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

2. Floor Drains: ASME A112.6.3.
4. Off-Floor Fixture Supports: ASME A112.6.1M.

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 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 of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 of each type installed.
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. Flushometer Tank, Repair Kits: Equal to 5 of each type installed.
6. Toilet Seats: Equal to 2 of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

1. Manufacturers: Subject to compliance with requirements, provide Delta single handle manual faucets, as scheduled no exceptions.

2.2 SINK FAUCETS

A. Sink Faucets:

1. Manufacturers: Subject to compliance with requirements, provide Delta single handle manual faucets, as scheduled no exceptions.

2.3 FLUSHOMETERS

A. Flushometers:

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

   a. Sloan Valve Company.
   b. Zum Plumbing Products Group; Commercial Brass Operation.
   c. TOTO USA, Inc.

2. Description: Flushometer for urinal and water-closet-type fixture shall be battery operated as scheduled, no exceptions. Include brass body with corrosion-resistant internal components, non-hold-open feature, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts.

   a. Internal Design: Diaphragm operation.
2.4 TOILET SEATS

A. Toilet Seats:

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:

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

3. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:

   a. American Standard Companies, Inc.
   b. Bemis Manufacturing Company.
   c. Centoco Manufacturing Corp.
   d. Church Seats.
   e. Eljer.
   f. Kohler Co.
   g. Olsonite Corp.
   i. Sperzel.
   k. Centoco Manufacturing Corp.
   l. Church Seats.
   m. Kohler Co.
   n. Olsonite Corp.
   o. Pressalit A/S.
   q. Sperzel.

4. Description: Toilet seat for water-closet-type fixture.

   a. Material: Molded, solid plastic with antimicrobial agent.
   b. Configuration: Open front without cover.
   c. Size: Elongated.
   d. Class: Standard commercial.
   e. Color: White.

2.5 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Piping Enclosures:

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:

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
3. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.6 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

B. Water-Closet Supports:

1. Description: Combination carrier designed for accessible and 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.

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.

D. Lavatory Supports:

1. Description: Type III, lavatory carrier with hanger plate and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

2.7 WATER CLOSETS

A. Water Closets:

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

   a. American Standard Companies, Inc.
   b. Eljer.
   c. Kohler Co.
   d. TOTO USA, Inc.
2.8 URINALS

A. Urinals:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard Companies, Inc.
   b. Eljer.
   c. Kohler Co.
   d. TOTO USA, Inc.

2.9 LAVATORIES

A. Lavatories:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard Companies, Inc.
   b. Eljer.
   c. Kohler Co.

2.10 BREAK ROOM SINKS

A. Break Room Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkay Manufacturing Co.
   b. Just Manufacturing Company.
   c. Moen, Inc.

2.11 SERVICE SINKS

A. Service Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard
   b. Mustee
   c. Fiat
   d. Terrazzo Wave, Inc.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install counter-mounting fixtures in and attached to casework.

G. Install fixtures level and plumb according to roughing-in drawings.

H. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
   1. Exception: Use ball, 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 "Common Work Results for Plumbing."

R. Set service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

S. 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 hot-water dispensers and 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.

E. Install fresh batteries in sensor-operated mechanisms.

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.

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END OF SECTION
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Piping materials and installation instructions common to most piping systems.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Sleeves.
   5. Escutcheons.
   7. Equipment installation requirements common to equipment sections.
   8. Painting and finishing.
   9. Concrete Bases.
   10. Supports and anchorages.

B. When used in these specifications the term “Provide” is defined to mean “furnish and install” materials, equipment, etc.

C. When noted on the drawings that items (materials, equipment, etc.) are owner furnished, this contractor shall install the item and shall provide all trade materials (pipe, fittings, nuts, bolts, etc.) necessary for a complete and operational system.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

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

F. The following are industry abbreviations for plastic materials:
   1. CPVC: Chlorinated polyvinyl chloride plastic.
   2. PE: Polyethylene plastic.
   3. PVC: Polyvinyl chloride plastic.

G. The following are industry abbreviations for rubber materials:
   1. EPDM: Ethylene-propylene-diene terpolymer rubber.
   2. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For the following:
   1. Transition fittings.
   2. Dielectric fittings.
   3. Mechanical sleeve seals.
   4. Escutcheons.

B. General: Follow the procedures specified in Division 1.

C. Prior to the performance of any work or installation of any materials, obtain approval from the Engineer by submitting shop drawings and data sheets.

D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the engineer of record will not be processed.

E. Any items with a tag number must be submitted for review. Submittals shall provide all pertinent data and information necessary to evaluate each item. In addition to the requirements outlined in the Division 1 sections and specific Division 23 sections, all submittals must indicate the applicable specification section number and equipment tag number.

F. Engineer's review of shop drawings does not release Contractor from responsibility of coordinating his work at jobsite and taking field measurements. In cases where interferences become apparent, the Contractor shall notify Engineer so that such interferences may be resolved prior to proceeding with shop work. No claim will be allowed for work that might have to be moved or replaced based on a claim that work was placed in accordance with dimensions shown on an approved shop drawing.

G. Welding certificates.

1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, “Structural Welding Code--Steel.”
B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

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

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate with the building trades:
   1. Structural members, pads, and building openings for mechanical equipment, ducts, piping, fans, etc., are the coordination responsibility of the contractor. Any changes in the above requirements will be paid for by the Contractor.
   2. The Drawings show the general arrangement, directions and sizes of Equipment, Ductwork, Piping, etc. It is not intended to show every offset and fitting of every site difficulty that may be encountered, but this Contractor shall furnish and install all materials and perform all labor necessary to make complete working systems, ready for use, without extra charge to the Owner or Engineer. All measurements must be verified on the jobsite.
   3. Examine the site and all drawings before proceeding with the layout and installation of this work to suit actual conditions. Confer and cooperate with other trades on the job so that all work will be installed in proper relationship. Precise location of parts to coordinate with other work is the responsibility of this Contractor. All systems shall be installed to provide maximum headroom, except where dimensioned otherwise on the drawings.
   4. Provide full time superintendent who shall oversee and coordinate the work with other trades and the Engineer.

E. Coordinate with electrical work:
   1. All motor starters, relays, contactors, etc. supplied as part of packaged equipment shall meet the requirements of the Division 26 Specifications.
2. All other motor starters, relays, contactors, etc. shall be provided under Division 26 specifications or as shown on the electrical drawings.

3. All control wiring for control devices, magnetic coils, damper operators, etc. shall not exceed 120 volts. Where power voltage for equipment is over 120 volts, a transformer shall be provided and wired for the controls.

4. Control wiring to solenoid and control valves, variable air volume terminals, damper operators, and all other control or controlled devices is to be provided under Division 23, in accordance with the requirements of Division 26, unless otherwise shown on the Electrical Drawings.

5. 120-volt power source for equipment will be made available, under Division 26, at the distribution breaker panels as indicated on the electrical drawings.

1.8 SITE EXAMINATION AND PRE-BID INSPECTION

A. This project consists of the construction of a new communications classroom building to simulate a "real world" news room and TV studio and includes the installation of roof top units and related piping and ductwork. Prior to submitting a bid for the proposed work, contractors shall examine the documents and construction site carefully, noting locations and conditions under which the work will be performed and accepting the responsibility for performing the work under the existing conditions.

B. Submittal of a bid indicates the contractor understands the scope and complexity of the work and accepts the responsibilities for performing the work under the existing conditions in accordance with all applicable codes and regulations, within the allotted schedule.

1.9 CONSTRUCTION PERMITS AND INSPECTIONS

A. Contractor shall file for and obtain all required permits and licenses, and pay all related inspection and permitting fees, as required for the execution of the contract. Arrange for necessary inspections required by City, County, State and other Authorities Having Jurisdiction in a timely manner and as required over the complete course of construction. Deliver inspection certificates and written approval notices to the Owner at contract closeout. Those items and systems deemed critical or required to obtain a completed Certificate of Occupancy shall take priority over non-critical items.

B. Any deficiencies noted by the various inspection departments, by the Engineer, or by Authorities Having Jurisdiction shall be addressed immediately and corrected in a timely fashion in order to avoid a delay in the construction sequence or in obtaining a Certificate of Occupancy.

1.10 WORKMANSHIP AND QUALIFICATIONS

A. All equipment, materials, specialties, etc., shall be installed and connected in accordance with the best engineering practice and standards for this type work. Unless otherwise specified or shown on the Drawings, the recommendations and instructions of the manufacturer shall be followed for installing the work.

B. Contractor shall be experienced and fully licensed to perform construction of the type and class required under this contract.

C. Contractor shall keep a competent superintendent and any necessary assistants satisfactory to the Owner and the Engineer in charge during the progress of the work. Contractor's superintendent shall properly coordinate and time the mechanical work with the work of other
trades and in particular with roofing and electrical work to avoid errors and delays. Contractor shall pay cost involved due to his failure to comply with these requirements or due to his failure to acquaint himself with the work in progress of the other trades.

D. All workmen shall be skilled in the task assigned them.

E. Work shall be completed in a neat, orderly and professional manner.

F. Should any dispute arise as to the quality or fitness of any material or workmanship, the decision shall rest with the Engineer.

G. Steel Support Welding: Qualify process and operators according to AWS D1.1. “Structural Welding Code – Steel.”

H. Steel Pipe Welding: Qualify process and operators according to ASME Boiler and Pressure Vessel Code: Section IX “Welding and Brazing Qualifications.” Comply with provisions in ASME B31 Series. “Code for Pressure Piping.” Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current. All welders employed for this work shall be qualified by the contractor under the qualification procedures specified by the American Welding Societies’ standard D10.9 Level AR-3. Evidence of welder’s qualifications shall be submitted to the Engineer before any welds are made.

1.11 SUBMITTALS

A. General: Follow the procedures specified in Division 1.

B. Prior to the performance of any work or installation of any materials, obtain approval from the Engineer by submitting shop drawings and data sheets.

C. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the engineer of record will not be processed.

D. Any items with a tag number must be submitted for review. Submittals shall provide all pertinent data and information necessary to evaluate each item. In addition to the requirements outlined in the Division 1 sections and specific Division 23 sections, all submittals must indicate the applicable specification section number and equipment tag number.

E. Engineer’s review of shop drawings does not release Contractor from responsibility of coordinating his work at jobsite and taking field measurements. In cases where interferences become apparent, the Contractor shall notify Engineer so that such interferences may be resolved prior to proceeding with shop work. No claim will be allowed for work that might have to be moved or replaced based on a claim that work was placed in accordance with dimensions shown on an approved shop drawing.

1.12 CONSTRUCTION DOCUMENTS.

A. The drawings for mechanical work are in part diagrammatic, intended to convey the scope of work and indicate general arrangement and approximate sizes and locations of equipment and materials. Where job conditions require reasonable changes in indicated locations and arrangement, the contractor shall make such changes as directed by the engineer, without additional cost to the Owner.
B. Because of the scale of the drawings, certain basic items such as pipe fittings, access panels, sleeves, etc. may not be shown; but where such items are required by the nature of the work, they shall be furnished and installed. Rough-in dimensions and locations shall be verified with the supplier of all equipment furnished by other trades, or by the owner, prior to the time of rough-in.

C. Equipment specifications may not deal individually with minute items required such as components, part, controls and devices which may be required to meet the equipment warranties. Where such items are required, they shall be included by the supplier of the equipment, whether or not specifically called for.

D. The drawings and the specifications are cooperative and supplementary. It is the intent of both said drawings and specifications to cover all mechanical requirements in their entirety as nearly as possible. The contractor shall closely check the drawings and specifications for any obvious errors or omissions and bring any such condition to the attention of the Engineer prior to the receipt of bid, in order to permit clarification by means of a mailed Addendum. If there are no questions prior to the bid proposal date, it shall be understood that the drawings and specifications are complete and correct, and that the intent of said documents will be complied with, and the installation to be complete in all respects, according to said intent. If there is a conflict between the drawings and specifications, the more stringent requirement shall govern, if not clarified in writing by the Engineer.

E. The Contractor shall locate all equipment which must be serviced, operated or maintained in full accessible positions. Minor deviations from the contract drawings may be made to allow for better accessibility, but changes of magnitude, or which involve extra cost, shall not be made without approval. Ample space shall be allowed for removal of all parts that may require replacement or service in the future.

1.13 RECORD DOCUMENTS

A. Record Drawings: Maintain a clean, undamaged set of blue or black line white-prints of Contract Drawings and Shop Drawings as required in Division 1 of these specifications. As the work progresses mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross-reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.

1. Mark new information that is important to the Owner, but was not shown on Contract Drawings or Shop Drawings. Include all change order items, bulletins, addenda, or field changes.

2. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set. Submit the record drawings as part of the project closeout package.

3. Ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.

4. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 23 Section "Mechanical Identification." Indicate actual inverts and horizontal locations of underground piping.

5. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
6. Approved substitutions, contract modifications, and actual equipment and materials installed.
7. Include all "Corrected For Record" shop drawings to reflect approvals received.

B. Engage the services of a Land Surveyor or Professional Engineer to record the locations and invert elevations of all underground installations.

C. Mark Specifications to indicate approved substitutions and actual equipment and materials used.

1.14 MAINTENANCE MANUALS

A. Organize operating and maintenance data into suitable sets of manageable size, meeting the requirements of Division 1. Bind properly indexed data in individual heavy-duty 2-inch, 3-ring vinyl-covered binders, with pocket folders for folded sheet information. Mark appropriate identification on front and spine of each binder. Include the following types of information:
1. Spare parts list.
2. Copies of warranties.
3. Wiring diagrams.
4. Inspection procedures.
5. Approved Shop Drawings and Product Data.
6. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
7. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
8. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
9. Servicing instructions and lubrication charts and schedules.
10. Provide an index for equipment which shall include the Manufacturer and local representative with address and telephone number.

1.15 WARRANTIES

A. Refer to Division 1 for procedures and submittal requirements for warranties. Refer to individual equipment specifications for warranty requirements.

B. Compile and assemble the warranties of equipment specified in Division 23, into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.

C. Provide complete warranty information for each item of product or equipment to include date of beginning of warranty or bond; duration of warranty or bond; and names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

D. This contractor shall provide warranty coverage on all materials and equipment installed, including owner furnished equipment, for a period of one (1) year from the date of substantial completion. The warranty shall cover the cost of labor and material for the repair or replacement of any and all defective materials.
1.16 PRODUCT LISTING

A. Prepare listing of major mechanical equipment and materials for the project.

B. When two or more items of same material or equipment are required, they shall be by the same manufacturer. Product manufacturer uniformity does not apply as applicable for project to raw materials, bulk materials, pipe, tube, fittings (except flanged and grooved types), sheet metal, wire, steel bar stock, welding rods, solder, fasteners, motors for dissimilar equipment units, and similar items used in work, except as otherwise indicated.

C. Provide products which are compatible with systems and other connected items.

1.17 NAMEPLATE DATA

A. Provide permanent operational data nameplate on each item of power operated mechanical equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplates in an accessible location.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

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

2.2 DESIGN BASIS

A. The products/materials specifically named in the specification and/or on the Drawings are the basis of design. The Engineer and/or Owner’s Representative reserves the right to reject product/materials, even if from other acceptable manufacturers, if it is felt they do not meet the intent of the specification.

B. The Engineer reserves the sole right for the approval of proposed material for equipment, and the phrase, "or an approved equivalent", used in these specifications, or on the drawings, shall be interpreted to mean an equivalent approved by the Engineer.

C. All changes required by alternate equipment shall be made at no additional cost to the owner; and all costs incurred by other trades, public utilities or the owner, as a result of the use of such equipment, shall be the responsibility of the contractor.

D. The Contractor shall identify the differences in alternate material or equipment as compared to that specified, and shall indicate the benefits to the project as a result of selecting the alternative.

E. The Engineer reserves the right to refuse approval of equipment which does not meet the specification, in his opinion, or of equipment for which no local experience of satisfactory service
is available. The Engineer further reserves the right to reject equipment for which maintenance service and the availability of replacement parts is questionable.

2.3 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 23 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.4 JOINING MATERIALS

A. Refer to individual Division 23 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).
1. Available Manufacturers:
   a. Capitol Manufacturing Co.
   b. Eclipse, Inc.
   c. Epco Sales, Inc.
   e. Watts Industries, Inc.; Water Products Div.
   f. Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

   1. Available Manufacturers:
      a. Capitol Manufacturing Co.
      b. Epco Sales, Inc.

E. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

   1. Available Manufacturers:
      a. Calpico, Inc.
      b. Lochinvar Corp.

F. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

   1. Available Manufacturers:
      a. Perfection Corp.
      b. Precision Plumbing Products, Inc.
      c. Sioux Chief Manufacturing Co., Inc.
      d. Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

   1. Available Manufacturers:
      a. Advance Products & Systems, Inc.
      b. Calpico, Inc.
      c. Metraflex Co.
      d. Pipeline Seal and Insulator, Inc.

   2. Sealing Elements: NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

   3. Pressure Plates: Carbon steel. Include two for each sealing element.
4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

   1. Underdeck Clamp: Clamping ring with set screws.

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

D. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.


   2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Insulated Piping: One-piece, stamped-steel type with spring clips.
   c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
   d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
   e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with exposed hinge and set screw.
   f. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated rough-brass finish.
   g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
   h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
M. Sleeves are not required for core-drilled holes.
N. Permanent sleeves are not required for holes formed by removable PE sleeves.
O. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.
   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
   a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
   b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.
2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.
3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

R. Verify final equipment locations for roughing-in.

S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA’s "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.


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

   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

   2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

   1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

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

   3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.


3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09 Sections "Interior Painting" and "Exterior Painting."

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

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
   1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.
   3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to supported equipment.
   6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
   7. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section" Cast-in-Place Concrete.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

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

END OF SECTION 230500
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.

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

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS
A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
B. Comply with NEMA MG 1 unless otherwise indicated.
C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS
A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.
2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.
   1. For motors with 2:1 speed ratio, consequent pole, single winding.
   2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

G. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F

J. Code Letter Designation:
   1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
   2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

K. Enclosure Material: Cast iron for motor frame sizes [324T] <Insert number> and larger; rolled steel for motor frame sizes smaller than [324T] <Insert number>.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
   1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
   2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.
2.5 SINGLE-PHASE MOTORS

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

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513
PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Sections:
   1. Division 23 Section "Facility Natural-Gas Piping" for gas meters.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. 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. Palmer - Wahl Instruments Inc.
   2. Trerice, H. O. Co.
   3. Weiss Instruments, Inc.
   4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
B. Case: Die-cast aluminum or brass 9 inches (229 mm) long.

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

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

E. Window: Glass.

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

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

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

2.2 THERMOWELLS

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

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.3 PRESSURE GAGES

A. 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. AMETEK, Inc.; U.S. Gauge Div.
3. Ernst Gage Co.
4. Eugene Ernst Products Co.
5. KOBOLD Instruments, Inc.
7. Miijoco Corp.
8. Noshok, Inc.
10. REO TEMP Instrument Corporation.
11. Trerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

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

1. Case: Liquid-filled type, drawn steel or cast aluminum 4-1/2-inch (114-mm) diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Pointer: Red or other dark-color metal.
7. Window: Glass.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
2. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.4 TEST PLUGS

A. 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. Flow Design, Inc.
2. MG Piping Products Co.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C)

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F (minus 7 to plus 93 deg C) shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F (minus 35 to plus 136 deg C) shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be 0 to 200 psig (0 to 1380 kPa).
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F (minus 4 to plus 52 deg C).
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F (minus 18 to plus 104 deg C).
4. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler and chiller.
3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
4. Inlet and outlet of each hydronic heat exchanger.
5. Inlet and outlet of each hydronic heat-recovery unit.
6. Inlet and outlet of each thermal storage tank.

B. Provide the following temperature ranges for thermometers:

1. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions.

3.2 GAGE APPLICATIONS

A. Install pressure gages at chilled water inlets and outlets of chillers.

B. Install pressure gages at suction and discharge of each pump.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

C. Install thermowells with socket extending a minimum of 2 inches (51 mm) into fluid and in vertical position in piping tees where thermometers are indicated.

D. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

E. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

F. Install test plugs in tees in piping.

G. Install connection fittings for attachment to portable indicators in accessible locations.

3.4 CONNECTIONS

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

A. Calibrate meters according to manufacturer's written instructions, after installation.

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

END OF SECTION 23 05 19
1.1 RELATED DOCUMENTS
   
   A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY
   
   A. Section Includes:
      1. Bronze ball valves.
      2. Iron, single-flange butterfly valves.
      4. Bronze lift check valves.
      5. Bronze swing check valves.
      7. Chainwheels.

   B. Related Sections:
      1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
      2. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.

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: Nonrising stem.
   E. OS&Y: Outside screw and yoke.
   F. RS: Rising stem.
   G. SWP: Steam working pressure.

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.

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 angle, gate, and globe valves closed to prevent rattling.
   4. Set ball and plug 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 HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
   1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
   2. Handwheel: For valves other than quarter-turn types.
   3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller.
   4. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:
1. 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.

F. Valve-End Connections:
   1. Flanged: With flanges according to ASME B16.1 for iron valves.
   2. Grooved: With grooves according to AWWA C606.
   4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE BALL VALVES

A. Three-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
   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:
      b. Hammond Valve.
      c. Milwaukee Valve Company.
      d. NIBCO INC.
      e. Red-White Valve Corporation.
   2. Description:
      b. SWP Rating: 150 psig (1035 kPa).
      c. CWP Rating: 600 psig (4140 kPa).
      d. Body Design: Three piece.
      e. Body Material: Bronze.
      f. Ends: Threaded.
      g. Seats: PTFE or TFE.
      h. Stem: Bronze.
      i. Ball: Chrome-plated brass.
      j. Port: Full.

2.3 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 150 CWP, Iron, Single-Flange Butterfly Valves with EPDM 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:
      b. Crane Co.; Crane Valve Group; Jenkins Valves.
      c. DeZurik Water Controls.
      d. Hammond Valve.
      e. Milwaukee Valve Company.
g. NIBCO INC.
h. Norriseal; a Dover Corporation company.
i. Red-White Valve Corporation.
j. Tyco Valves & Controls; a unit of Tyco Flow Control.
k. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 150 psig (1035 kPa).
c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
d. Body Material: ASTM A 126, cast iron or ASTM A 536, ductile iron.
e. Seat: EPDM.
f. Stem: One- or two-piece stainless steel.
g. Disc: Aluminum bronze.
h. Threaded lug-style body rated for dead-end services.

2.4 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, 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: 175 psig (1200 kPa).
   c. Body Material: Coated, ductile iron.
   e. Disc: Coated, ductile iron.
   f. 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 1.
b. CWP Rating: 200 psig (1380 kPa).
e. Ends: Threaded.
f. 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. American Valve, Inc.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Crane Co.; Crane Valve Group; Jenkins Valves.
   d. Crane Co.; Crane Valve Group; Stockham Division.
   e. Hammond Valve.
   f. Milwaukee Valve Company.
   g. NIBCO INC.
   h. Powell Valves.
   i. Red-White Valve Corporation.
   j. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Horizontal flow.
   e. Ends: Threaded.
   f. Disc: Bronze.

2.7 IRON, PLATE-TYPE CHECK VALVES

A. Class 150, Iron, Dual-Plate Check Valves with Metal Seat:

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. APCO Willamette Valve and Primer Corporation.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Mueller Steam Specialty; a division of SPX Corporation.
   d. Val-Matic Valve & Manufacturing Corp.

2. Description:
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 300 psig (2070 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 250 psig (1725 kPa).
2.8 CHAINWHEELS

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. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to butterfly valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
4. Chain: Stainless 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 butterfly valves NPS 6 and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor.
F. 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. Shutoff Service: Ball, butterfly valves.
3. Pump-Discharge Check Valves:
   a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal or resilient-seat check valves.

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 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
4. For Steel Piping, NPS 2-1/2 and larger: Flanged ends.
5. For Grooved-End Copper Tubing and Steel Piping except Steam and Steam Condensate Piping: Valve ends may be grooved.

END OF SECTION 23 05 23
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 1 Specification Sections, apply to this Section.

1.2 SUMMARY

   A. This Section includes the following hangers and supports for HVAC system piping and equipment:

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

   B. Related Sections include the following:

   1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
   2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-protection piping.
   3. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
   4. Division 23 Section(s) "Metal Ducts for duct hangers and supports.

1.3 DEFINITIONS

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

   B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

   A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

   B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

   C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.
1.5 SUBMITTALS

A. Product Data: For the following:
   1. Steel pipe hangers and supports.
   2. Thermal-hanger shield inserts.
   3. Powder-actuated fastener systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
   1. Trapeze pipe hangers. Include Product Data for components.
   2. Metal framing systems. Include Product Data for components.
   3. Pipe stands. Include Product Data for components.
   4. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

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

B. Welding: Qualify procedures and personnel according to the following:
   1. AWS D1.1, "Structural Welding Code--Steel."
   2. AWS D1.3, "Structural Welding Code--Sheet Steel."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers:
   2. Carpenter & Paterson, Inc.
   3. Empire Industries, Inc.
   4. ERICO/Michigan Hanger Co.
5. Globe Pipe Hanger Products, Inc.
6. Grinnell Corp.
7. GS Metals Corp.
9. PHD Manufacturing, Inc.
10. PHS Industries, Inc.
11. Piping Technology & Products, Inc.

C. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

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

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:

2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
5. Thomas & Betts Corporation.
6. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated. All support assemblies located outdoors shall be hot-dipped galvanized after fabrication.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- (690-kPa-) minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Available Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.
C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

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 (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.6 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.

1. Available Manufacturers:
   a. Hilti, Inc.
   b. ITW Ramset/Red Head.
   c. Masterset Fastening Systems, Inc.
   d. MKT Fastening, LLC.
   e. Powers Fasteners.

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

1. Available Manufacturers:
   b. Empire Industries, Inc.
   c. Hilti, Inc.
   d. ITW Ramset/Red Head.
   e. MKT Fastening, LLC.
   f. Powers Fasteners.

2.7 EQUIPMENT SUPPORTS

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

2.8 MISCELLANEOUS MATERIALS

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

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.

B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN 100 to DN 400), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN 20 to DN 600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN 15 to DN 600), if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2 (DN 15 to DN 50).
10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 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 20 (DN 65 to DN 500), from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN 50 to DN 600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN 50 to DN 750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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 (49 to 232 deg C) piping installations.

I. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
   a. Light (MSS Type 31): 750 lb (340 kg).
   b. Medium (MSS Type 32): 1500 lb (680 kg).
   c. Heavy (MSS Type 33): 3000 lb (1360 kg).
13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. 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.

K. 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 (32 mm).
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 absorb 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 absorb 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 absorb 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.

L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.2 HANGER AND SUPPORT INSTALLATION

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

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.
   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
   2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:
   1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Install hangers and supports complete with necessary 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 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

K. Load Distribution: Install hangers and supports so 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 so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.
   a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
   c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:
   a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
   b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
   c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
   d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood inserts.
6. Insert Material: Length at least as long as protective shield.
7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.
3.4 METAL FABRICATIONS

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

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

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

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.6 PAINTING

A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touch Up: 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.

END OF SECTION 23 05 29
SECTION 23 05 48
VIBRATION-SEISMIC CONTROLS 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. This Section includes the following:
   1. Elastomeric hangers.
   2. Restrained vibration isolation roof-curb rails.
   3. Restraining braces and cables.

1.3 DEFINITIONS
C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS
A. Wind-Restraint Loading:
   1. Basic Wind Speed: 90 MPH.
   2. Building Classification Category: II.
   3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.
      a. Component Importance Factor: 1.0
      b. Component Response Modification Factor: 1.5.
3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.278.
4. Design Spectral Response Acceleration at 1-Second Period: 0.096.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by [an evaluation service member of ICC-ES] [OSHPD] [an agency acceptable to authorities having jurisdiction].
   b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic[ and wind] forces required to select vibration isolators, seismic[ and wind] restraints, and for designing vibration isolation bases.
   a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.
2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic[- and Wind]-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic[ and wind] restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Division 22 Sections for equipment mounted outdoors.

d. Preapproval and Evaluation Documentation: By [an evaluation service member of ICC-ES] [OSHPD] [an agency acceptable to authorities having jurisdiction], showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.

E. Qualification Data: For [professional engineer] [and] [testing agency].

F. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data [performed by an independent agency].

G. Field quality-control test reports.

H. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

B. Restrained Spring Isolators <Insert drawing designation>: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
   1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
   2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
   3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

C. Elastomeric Hangers <Insert drawing designation>: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

2.2 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

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

   1. Amber/Booth Company, Inc.
   2. California Dynamics Corporation.
   3. Isolation Technology, Inc.
   5. Mason Industries.
   6. Thybar Corporation.
   7. Vibration Eliminator Co., Inc.
   8. Vibration Isolation.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic[ and wind] forces. Lower support
assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches (50 mm) of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- (6-mm-) thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind restraint.
   a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
   b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
   c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
   d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
   e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.3 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by OSHPD.
1. **Structural Safety Factor:** Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. **Snubbers:** Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
   1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
   2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
   3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

D. **Channel Support System:** MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

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

F. **Hanger Rod Stiffener:** Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

G. **Resilient Isolation Washers and Bushings:** One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

H. **Mechanical Anchor Bolts:** Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

I. **Adhesive Anchor Bolts:** Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4 **FACTORY FINISHES**

A. **Finish:** Manufacturer's standard prime-coat finish ready for field painting.

B. **Finish:** Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic[- and wind]-control devices to indicate capacity range.
PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by OSHPD.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Division 07 Section “Roof Accessories” for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install seismic-restraint devices using methods approved by OSHPD providing required submittals for component.

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of 40 feet (12 m) o.c., and longitudinal supports a maximum of 80 feet (24 m) o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by OSHPD providing required submittals for component.
F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 22 Section "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days’ advance notice.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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

E. Prepare test and inspection reports.

3.6 ADJUSTING

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

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 DEMONSTRATION

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

END OF SECTION 230548
SECTION 23 05 53
IDENTIFICATION FOR HVAC 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.

B. Division 23 section “Common Work Results for HVAC Systems” applies to work of this section.

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Stencils.
3. Valve Taps.

1.3 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacturer of identification devices of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards: Comply with ANSI A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

1.4 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.
1.3 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturer: Subject to compliance with requirements, provide mechanical identification materials of one of the following:

1. Allen Systems, Inc.
3. Industrial Safety Supply Co., Inc.
4. Seton Name Plate Corp.

2.2 MECHANICAL IDENTIFICATION MATERIALS

A. General: Provide manufacturer's standard products of categories and types required for each application as referenced in other Division-23 sections. Where more than single type is specified for application, selection is Installer's option, but provide single selection for each product category.

2.3 PAINTED IDENTIFICATION MATERIALS

A. Stencils: Standard fiberboard stencils, prepared for required applications with letter sizes generally complying with recommendations of ANSI A13.1 for piping and similar applications, but not less than 1-1/4" high letters for ductwork and not less than 3/4" high letters for access door signs and similar operational instructions.

B. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

C. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ANSI A13.1 for colors.

2.4 PLASTIC PIPE MARKERS

A. Snap-On Type: Provide manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers, complying with ANSI A13.1.

B. Pressure-Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color-coded, and pressure-sensitive vinyl pipe markers, complying with ANSI A13.1.
C. Small Pipes: For external diameters less than 6" (including insulation if any), provide full-band pipe markers, extending 360 degrees around pipe at each location, fastened by one of the following methods:

1. Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2. Adhesive lap joint in pipe marker overlap.
3. Laminated or bonded application of pipe marker to pipe (or insulation).
4. Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4" wide; full circle at both ends of pipe marker, tape lapped 1-1/2".

D. Lettering: Manufacturer's standard pre-printed nomenclature, which best describes piping system in each instance, as selected by A/E in cases of variance with name as shown or specified.

1. Arrows: Print each pipe marker with arrows indicating direction of flow, either integrally with piping system service lettering (to accommodate both directions), or as separate unit of plastic.

2.5 PLASTIC TAPE

A. General: Provide manufacturer's standard color-coded pressure-sensitive (self-adhesive) vinyl tape, not less than 3 mils thick.

B. Width: Provide 1-1/2" wide tape markers on pipes with outside diameters (including insulation, if any) of less than 6", 2-1/2" wide tape for larger pipes.

C. Color: Comply with ANSI A13.1, except where another color selection is indicated.

2.6 PLASTIC EQUIPMENT MARKERS

A. General: Provide manufacturer's standard laminated plastic, color-coded equipment markers. Conform to the following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.

B. Nomenclature: Include the following, matching terminology on schedules as closely as possible:

1. Name and plan number.
2. Equipment service.
3. Design capacity.
4. Other design parameters such as pressure drop, entering and leaving conditions, rpm, etc.

C. Size: Provide approximate 2-1/2" x 4" markers for control devices, dampers, and valves; 4-1/2" x 6" for equipment.

2.7 LETTERING AND GRAPHICS

A. General: Coordinate names, abbreviations and other designations used in mechanical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by
manufacturers or as required for proper identification and operation/maintenance of mechanical systems and equipment. Where multiple systems of same generic name are shown and specified, provide identification, which indicates individual system number as well as service (as examples; Boiler No. 3, Air Supply No. 1H, Standpipe F12).

1.4 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Thickness: Brass, 0.032-inch, Stainless steel, 0.025-inch, or Aluminum, 0.032-inch, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 3 by 1 inch.
   5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:
   1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
   2. Letter Color: Black.
   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 3 by 1 inch.
   8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

C. Label Content: Include equipment's Drawing designation or unique equipment number, and Drawing numbers where equipment is indicated (plans, details, and schedules).

1.5 STENCILS


PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. Coordination: Where identification is to be applied to surfaces, which require insulation, painting or other covering or finish, including valve tags in finished mechanical spaces, install identification after completion of covering and painting. Install identification prior to installation of acoustical ceilings and similar removable concealment.

B. Piping in the Central Plant and other equipment rooms shall be painted to match the existing color scheme. Division 15 contractor shall cooperate and coordinate with the General Contractor regarding equipment room and other mechanical equipment finish requirements.
3.2 PIPING SYSTEM IDENTIFICATION

A. General: Install pipe markers of one of the following types on each system and include arrows to show normal direction of flow:
   1. Stenciled markers, including color-coded background band or rectangle, and contrasting lettering of black or white. Extend color band or rectangle 2" beyond ends of lettering.
   2. Stenciled markers, with lettering color complying with ANSI A13.1.
   3. Plastic pipe markers, with application system as indicated under "Materials" in this section. Install on pipe insulation segment where required for hot non-insulated pipes. Stenciled markers, black or white for best contrast, wherever continuous color-coded painting of piping is provided.
   4. Paint all new chilled water and condenser water piping inside the central plant to match the existing chilled water and condenser water piping.

B. Locate pipe markers and color bands as follows wherever piping is exposed to view in occupied spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.
   1. Near each valve and control device.
   2. Near each branch, excluding short take-offs for fixtures and terminal units; mark each pipe at branch, where there could be question of flow pattern.
   3. Near locations where pipes pass through walls or floors/ceilings, or enter non-accessible 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 intermittently at maximum spacing of 50' along each piping run, except reduce spacing to 25' in congested areas of piping and equipment.

3.3 MECHANICAL EQUIPMENT IDENTIFICATION

A. General: Install engraved plastic laminate sign or plastic equipment marker on or near each major item of mechanical equipment and each operational device.

B. Optional Sign Types: Where lettering larger than 1" height is needed for proper identification, because of distance from normal location of required identification, stenciled signs may be provided in lieu of engraved plastic, at Installer's option.

C. Lettering Size: Minimum 1/4" high lettering for name of unit where viewing distance is less than 2'-0", 1/2" high for distances up to 6'-0", and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.

D. Text of Signs: In addition to name of identified unit, provide lettering to distinguish between multiple units, electrical circuit feeding device, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

3.5 ADJUSTING AND CLEANING
A. Adjusting: Relocate any mechanical identification device, which has become visually blocked by work of this division or other divisions.

B. Cleaning: Clean face of identification devices, and glass frames of valve charts.

END OF SECTION 23 05 53
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. This Section includes TAB to produce design objectives for the following:
   1. Air Systems:
      a. Constant-volume air systems.
      b. Variable-air-volume systems.
   2. Hydronic Piping Systems:
      a. Constant-flow systems.
      b. Variable-flow systems.
   3. Verifying that automatic control devices are functioning properly.
   4. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS
A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
E. NC: Noise criteria.
F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
G. RC: Room criteria.
H. Report Forms: Test data sheets for recording test data in logical order.

I. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

J. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

K. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

L. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

M. TAB: Testing, adjusting, and balancing.

N. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

O. Test: A procedure to determine quantitative performance of systems or equipment.

P. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.


C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.

D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

E. Sample Report Forms: Submit two sets of sample TAB report forms.

F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. TAB Firm Qualifications: Engage a TAB firm certified by AABC, NEBB, or TABB.

B. TAB Conference: Meet with Owner's and Architect's representatives on approval of TAB strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of TAB team members, equipment manufacturers’ authorized service representatives; HVAC controls installers, and other support personnel. Provide seven days' advance notice of scheduled meeting time and location.
1. Agenda Items: Include at least the following:
   a. Submittal distribution requirements.
   c. TAB plan.
   d. Work schedule and Project-site access requirements.
   e. Coordination and cooperation of trades and subcontractors.
   f. Coordination of documentation and communication flow.

C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard forms from TAB firm's forms approved by Engineer.

E. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," Section II, "Required Instrumentation for NEBB Certification ."

F. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
   1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

H. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Owner Occupancy: Owner may partially occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. The Test and Balance Contractor shall contract directly with the owner, not thru the General Contractor (GC) or Mechanical Contractor (MC). The GC and MC shall coordinate with the TAB contractor and shall provide access as required in a timely fashion to meet the project schedule.

1.7 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems’ designs that may preclude proper TAB of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of Contract.

2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of HVAC systems and equipment.

C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

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 equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

G. Examine system and equipment test reports.

H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

L. Examine strainers for clean screens and proper perforations.

M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

N. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

O. Examine system pumps to ensure absence of entrained air in the suction piping.

P. Examine equipment for installation and for properly operating safety interlocks and controls.

Q. Examine automatic temperature system components to verify the following:
   1. Dampers, valves, and other controlled devices are operated by the intended controller.
   2. Dampers and valves are in the position indicated by the controller.
   3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
   4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
   5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
   6. Sensors are located to sense only the intended conditions.
   7. Sequence of operation for control modes is according to the Contract Documents.
   8. Controller set points are set at indicated values.
   9. Interlocked systems are operating.
   10. Changeover from heating to cooling mode occurs according to indicated values.

R. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:
   1. Permanent electrical power wiring is complete.
   2. Hydronic systems are filled, clean, and free of air.
   3. Automatic temperature-control systems are operational.
   4. Equipment and duct access doors are securely closed.
   5. Balance, smoke, and fire dampers are open.
   6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

### 3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

### 3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.

E. Check airflow patterns from the outside-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. Check for proper sealing of air duct system.
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 fan static pressures to determine actual static pressure as follows:
   a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
   a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Architect for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer’s written instructions and calculating factors.
D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum and return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
   a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

3.7 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.
C. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.8 PROCEDURES FOR HYDRONIC SYSTEMS

A. Measure water flow using the following procedures:

1. Check system resistance. With all valves open, read pressure differential across the coil. Adjust balance valve until indicated water flow is achieved.
2. Report flow rates that are not within plus or minus 5 percent of design.

B. Set calibrated balancing valves, if installed, at calculated presettings.

C. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

D. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

E. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

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. Measure water flow through all circuits.

C. Adjust water flow to within specified tolerances.

D. Measure inlet and outlet water temperatures.
E. Check the setting and operation of safety and relief valves. Record settings.

3.10 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer, model, and serial numbers.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.11 PROCEDURES FOR HEAT-TRANSFER COILS

A. Water Coils: Measure the following data for each coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils.
6. Airflow.
7. Air pressure drop.

B. Refrigerant Coils: Measure the following data for each coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.12 PROCEDURES FOR TEMPERATURE MEASUREMENTS

A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

C. Measure outside-air, wet- and dry-bulb temperatures.
3.13 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.
B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
C. Record controller settings and note variances between set points and actual measurements.
D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
E. Check free travel and proper operation of control devices such as damper and valve operators.
F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
G. Check the interaction of electrically operated switch transducers.
H. Check the interaction of interlock and lockout systems.
I. Check main control supply-air pressure and observe compressor and dryer operations.
J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.
K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.14 TOLERANCES

A. Set HVAC system airflow and water flow rates within the following tolerances:
   1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
   2. Air Outlets and Inlets: Minus 5 to plus 10 percent.
   3. Heating-Water Flow Rate: Minus 5 to plus 10 percent.
   4. Cooling-Water Flow Rate: Minus 5 to plus 10 percent.

3.15 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: As Work progresses, prepare 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.
3.16 FINAL REPORT

A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.

B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field report data, include the following:
   1. Fan curves.
   2. Manufacturers’ test data.
   3. Field test reports prepared by system and equipment installers.
   4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
   1. Title page.
   2. Name and address of TAB firm.
   3. Project name.
   4. Project location.
   5. Architect’s name and address.
   6. Engineer’s name and address.
   7. Contractor’s name and address.
   9. Signature of TAB firm 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, type size, and fittings.
   14. Notes to explain why certain final data in the body of reports varies from indicated values.
   15. Test conditions for fans and pump performance forms including the following:
       a. Settings for outside-, 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.

E. 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 outside, supply, return, and exhaust airflows.
2. Water flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.

F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data: Include the following:
   a. Unit identification.
   b. Location.
   c. Make and type.
   d. Model number and unit size.
   e. Manufacturer's serial number.
   f. Unit arrangement and class.
   g. Discharge arrangement.
   h. Sheave make, size in inches (mm), and bore.
   i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
   j. Number of belts, make, and size.
   k. Number of filters, type, and size.

2. Motor Data:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
   e. Filter static-pressure differential in inches wg (Pa).
   f. Preheat coil static-pressure differential in inches wg (Pa).
   g. Cooling coil static-pressure differential in inches wg (Pa).
   h. Heating coil static-pressure differential in inches wg (Pa).
   i. Outside airflow in cfm (L/s).
   j. Return airflow in cfm (L/s).
   k. Outside-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

G. Apparatus-Coil Test Reports:

1. Coil Data:
   a. System identification.
   b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch (mm) o.c.
f. Make and model number.
g. Face area in sq. ft. (sq. m).
h. Tube size in NPS (DN).
i. Tube and fin materials.
j. Circuiting arrangement.

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Average face velocity in fpm (m/s).
   c. Air pressure drop in inches wg (Pa).
   d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
   e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
   f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
   g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
   h. Water flow rate in gpm (L/s).
   i. Water pressure differential in feet of head or psig (kPa).
   j. Entering-water temperature in deg F (deg C).
   k. Leaving-water temperature in deg F (deg C).
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig (kPa).
   n. Refrigerant suction temperature in deg F (deg C).

H. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.
   g. Sheave make, size in inches (mm), and bore.
   h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

2. Motor Data:
   a. Make and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.
   e. Sheave make, size in inches (mm), and bore.
   f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
   g. Number of belts, make, and size.

3. Test Data (Indicated and Actual Values):
   a. Total airflow rate in cfm (L/s).
   b. Total system static pressure in inches wg (Pa).
   c. Fan rpm.
   d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
   a. System and air-handling unit number.
   b. Location and zone.
   c. Traverse air temperature in deg F (deg C).
   d. Duct static pressure in inches wg (Pa).
   e. Duct size in inches (mm).
   f. Duct area in sq. ft. (sq. m).
   g. Indicated airflow rate in cfm (L/s).
   h. Indicated velocity in fpm (m/s).
   i. Actual airflow rate in cfm (L/s).
   j. Actual average velocity in fpm (m/s).
   k. Barometric pressure in psig (Pa).

J. Air-Terminal-Device Reports:

1. Unit Data:
   a. System and air-handling unit identification.
   b. Location and zone.
   c. Test apparatus used.
   d. Area served.
   e. Air-terminal-device make.
   f. Air-terminal-device number from system diagram.
   g. Air-terminal-device type and model number.
   h. Air-terminal-device size.
   i. Air-terminal-device effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):
   a. Airflow rate in cfm (L/s).
   b. Air velocity in fpm (m/s).
   c. Preliminary airflow rate as needed in cfm (L/s).
   d. Preliminary velocity as needed in fpm (m/s).
   e. Final airflow rate in cfm (L/s).
   f. Final velocity in fpm (m/s).
   g. Space temperature in deg F (deg C).

K. 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 (L/s).
b. Entering-water temperature in deg F (deg C).
c. Leaving-water temperature in deg F (deg C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in deg F (deg C).
f. Leaving-air temperature in deg F (deg C).

3. Air-Cooled Condenser Test Data (Indicated and Actual Values):
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering- and leaving-air temperature in deg F (deg C).

4. Evaporator Test Reports (Indicated and Actual Values):
   a. Refrigerant pressure in psig (kPa).
   b. Refrigerant temperature in deg F (deg C).
   c. Entering-water temperature in deg F (deg C).
   d. Leaving-water temperature in deg F (deg C).
   e. Water pressure drop in feet of head or psig (kPa).

5. Compressor Test Data (Indicated and Actual Values):
   a. Suction pressure in psig (kPa).
   b. Suction temperature in deg F (deg C).
   c. Discharge pressure in psig (kPa).
   d. Discharge temperature in deg F (deg C).
   e. Oil pressure in psig (kPa).
   f. Oil temperature in deg F (deg C).
   g. Voltage at each connection.
   h. Amperage for each phase.
   i. Kilowatt input.
   j. Crankcase heater kilowatt.
   k. Chilled-water control set point in deg F (deg C).
   l. Condenser-water control set point in deg F (deg C).
   m. Refrigerant low-pressure-cutoff set point in psig (kPa).
   n. Refrigerant high-pressure-cutoff set point in psig (kPa).

6. Refrigerant Test Data (Indicated and Actual Values):
   a. Oil level.
   b. Refrigerant level.
   c. Relief valve setting in psig (kPa).
   d. Unloader set points in psig (kPa).
   e. Percentage of cylinders unloaded.
   f. Bearing temperatures in deg F (deg C).
   g. Vane position.
   h. Low-temperature-cutoff set point in deg F (deg C).

L. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, or water-cooled condensing units, include the following:

1. Unit Data:
a. Unit identification.
b. Location.
c. Unit make and model number.
d. Compressor make.
e. Compressor model and serial numbers.
f. Refrigerant weight in lb (kg).
g. Low ambient temperature cutoff in deg F (deg C).

2. Test Data (Indicated and Actual Values):
a. Inlet-duct static pressure in inches wg (Pa).
b. Outlet-duct static pressure in inches wg (Pa).
c. Entering-air, dry-bulb temperature in deg F (deg C).
d. Leaving-air, dry-bulb temperature in deg F (deg C).
e. Condenser entering-water temperature in deg F (deg C).
f. Condenser leaving-water temperature in deg F (deg C).
g. Condenser-water temperature differential in deg F (deg C).
h. Condenser entering-water pressure in feet of head or psig (kPa).
i. Condenser leaving-water pressure in feet of head or psig (kPa).
j. Condenser-water pressure differential in feet of head or psig (kPa).
k. Control settings.
l. Unloader set points.
m. Low-pressure-cutout set point in psig (kPa).
n. High-pressure-cutout set point in psig (kPa).
o. Suction pressure in psig (kPa).
p. Suction temperature in deg F (deg C).
q. Condenser refrigerant pressure in psig (kPa).
r. Condenser refrigerant temperature in deg F (deg C).
s. Oil pressure in psig (kPa).
t. Oil temperature in deg F (deg C).
u. Voltage at each connection.
v. Amperage for each phase.
w. Kilowatt input.
x. Crankcase heater kilowatt.
y. Number of fans.
z. Condenser fan rpm.
aa. Condenser fan airflow rate in cfm (L/s).
bb. Condenser fan motor make, frame size, rpm, and horsepower.
cc. Condenser fan motor voltage at each connection.
dd. Condenser fan motor amperage for each phase.

M. Instrument Calibration Reports:

1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.17 INSPECTIONS

A. Initial Inspection:
1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.

2. Randomly check the following for each system:
   a. Measure airflow of at least 10 percent of air outlets.
   b. Measure water flow of at least 5 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Verify that balancing devices are marked with final balance position.
   e. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Owner or Engineer.

2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner or Engineer.

3. Owner or Engineer shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.

4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.

7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.18 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION 230593
SECTION 23 07 00
HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1 Specification Sections, and all other Division 23 sections apply to work of this section.

1.2 SUMMARY

A. Extent of mechanical insulation required by this section is indicated on drawings and schedules, and by requirements of this section.

B. Types of mechanical insulation specified in this section include the following:

1. Piping System Insulation:
   a. Fiberglass.
   b. Flexible Unicellular.

2. Ductwork System Insulation:
   a. Fiberglass.

C. Refer to Division-23 section "Hangers and Supports for HVAC" for protection saddles, protection shields, and thermal hanger shields; not work of this section.

D. Refer to Division-23 section "Identification for HVAC" for installation of identification devices for piping, ductwork, and equipment; not work of this section.

1.3 QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E 84 (NFPA 255) method.

1. Exception: Outdoor mechanical insulation may have flame-spread index of 75 and smoke developed index of 150.

C. Plenum Ratings: Provide product approved for installation in air plenums where applicable.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver insulation, coverings, cements, adhesives, and coatings to site in containers with manufacturer's stamp or label, affixed showing fire hazard indexes of products.

B. Protect insulation against dirt, water, and chemical and mechanical damage. Do not install damaged or wet insulation; remove from project site.
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

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

1. Armstrong World Industries, Inc.
2. CertainTeed Corp.
3. Knauf Fiber Glass GmbH.
4. Owens-Corning Fiberglas Corp.

2.2 PIPING INSULATION MATERIALS

A. Fiberglass Piping Insulation: ASTM C 547; 'k' value of 0.24 at 75 degrees F; noncombustible.
B. Flexible Unicellular Piping Insulation: ASTM C 534; flexible, elastomeric; 'k' value of 0.27 at 75 degrees F., water vapor permeability = 0.1 perm, density 4.5 lb/FT³.
C. Jackets for Piping Insulation: ASTM C 921, Type I (vapor barrier) for piping with temperatures below ambient, Type II for piping with temperatures above ambient. Type I may be used for all piping at Installers option.
1. Encase pipefittings insulation with one-piece premolded PVC fitting covers, fastened as per manufacturer's recommendations.
2. Encase exterior piping insulation with aluminum jacket with weather-proof construction.
3. Exterior piping jacket shall be Aluminum alloy 5005-H16 with smooth finish. Thickness shall be 0.016 inch for 12.75 inch O.D. and smaller and have factory applied vapor barrier liner.
D. Bands, Wires, and Cement: As recommended by insulation manufacturer for applications indicated. No staples shall be allowed.
E. Adhesives, Sealers, and Protective Finishes: As recommended by insulation manufacturer for applications indicated.

2.3 DUCTWORK INSULATION MATERIALS

A. Rigid Fiberglass Ductwork Insulation: ASTM C 612; 'k' Value of 0.24 at 75 F, 3 lb/cu.ft. minimum density, non-combustible, rigid, ASJ jacket.
B. Flexible Fiberglass Ductwork Insulation: ASTM C 553, Type I, Class B-4, 1.5 lbs per cubic foot, 'k' Value of 0.3 at 75 F, FSK jacket, non-combustible, flexible.
C. Jackets for Ductwork Insulation: ASTM C 921, Type I (vapor barrier type) for ductwork with temperatures below ambient; Type II (water vapor permeable) for ductwork with temperatures above ambient.
D. Ductwork Insulation Accessories: Provide staples, bands, wires, tape, anchors, corner angles and similar accessories as recommended by insulation manufacturer for applications indicated.
E. Ductwork Insulation Compounds: Provide cements, adhesives, coatings, sealers, protective finishes and similar compounds as recommended by insulation manufacturer for applications indicated.
PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which mechanical insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 PIPING SYSTEM INSULATION, GENERAL

A. Insulation Omitted: Omit insulation on chrome-plated exposed piping (except for handicapped fixtures), air chambers, unions, strainers, check valves, balance cocks, flow regulators, drain lines from water coolers, drainage piping located in crawl spaces or tunnels, buried piping, fire protection piping, and pre-insulated equipment.

B. The installed R-value of all pipe insulation shall be in accordance with the requirements of the 2012 International Energy Conservation Code (IECC).

3.3 PIPE INSULATION APPLICATION SCHEDULE

A. Insulate piping according to the following insulation application schedule:

<table>
<thead>
<tr>
<th>TEMP RANGE</th>
<th>SERVICE</th>
<th>INSUL TYPE</th>
<th>PIPE SIZE</th>
<th>INSUL THICKNESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold</td>
<td>Chilled Water, above ground</td>
<td>FG</td>
<td>1” &amp; less</td>
<td>1”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 ½” – 2”</td>
<td>1 ½”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 ½” &amp; above</td>
<td>2”</td>
</tr>
<tr>
<td>40°F to Ambient</td>
<td>Air Conditioning Condensate Drain</td>
<td>FG</td>
<td>4” &amp; less</td>
<td>1”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>UC</td>
<td>1” &amp; less</td>
<td>¾”</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Over 1”</td>
<td>1”</td>
</tr>
</tbody>
</table>

3.4 INSULATION OF PIPING EXPOSED TO WEATHER

A. Protect outdoor insulation from weather by installing aluminum outdoor protective finish or jacketing with installation as recommended by the manufacturer.

3.5 INSTALLATION OF PIPING INSULATION

A. General: Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.

C. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with single cut piece to complete run. Do not use cut pieces or scraps abutting each other.

D. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

E. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage.
F. Cover valves, fittings and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job fabricated units (at Installer's option) except where specific form or type is indicated.

G. Extend piping insulation without interruption through walls, floors and similar piping penetrations, except where otherwise indicated.

H. Piping Exposed to Weather: Protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by manufacturer.

I. Protect outside unicellular insulation with two coats of finish over glass mesh, which has been adhered to the insulation with adhesive.

J. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3” wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3” wide vapor barrier tape or band.

3.6 DUCTWORK SYSTEM INSULATION, GENERAL

A. Insulation Omitted: Do not insulate fibrous glass ductwork, lined ductwork, and factory insulated unit casings.

B. The installed R-valve of all pipe insulation shall be in accordance with the requirements of the 2012 International Energy Conservation Code (1ECC).

3.7 DUCTWORK INSULATION APPLICATION SCHEDULE

A. Insulate ductwork according to the following insulation application schedule:

<table>
<thead>
<tr>
<th>TEMP RANGE</th>
<th>SERVICE</th>
<th>INSUL TYPE</th>
<th>INSUL THICKNESS</th>
</tr>
</thead>
</table>
| Cold Duct  | -Outdoor air intake ductwork between air entrance and fan inlet or HVAC unit inlet  
- HVAC supply ductwork between fan discharge, or HVAC unit discharge and room terminal outlet.  
- Neck and bells of supply diffusers.  
- HVAC return ductwork between room terminal inlet and return fan inlet or HVAC unit inlet.  
- HVAC plenums or unit housings not pre-insulated at factory or lined. | RFG FFG   | 1 ½” 1 ½”       |
| Cold Duct  | -Exposed spiral duct  
(Certain feed “Tough Guard Ultra Round” spiral duct liner) | RFG       | 1”              |

3.8 INSTALLATION OF DUCTWORK INSULATION

A. Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulating. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation, and protect it to prevent puncture and other damage.
E. Extend ductwork insulation without interruption through walls, floors and similar ductwork penetrations, except where otherwise indicated.

F. Lined Ductwork: Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

G. Flexible fiberglass duct insulation to be installed in concealed locations only.

3.9 PROTECTION AND REPLACEMENT

A. Replace damaged insulation, which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture-saturated units.

B. Protection: Insulation Installer shall advise Contractor of required protection for insulation work during remainder of construction period, to avoid damage and deterioration.

END OF SECTION 23 07 00
SECTION 23 09 20
INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 DESCRIPTION OF WORK
A. This project shall include all materials and labor necessary to interface the new HVAC equipment with the existing Andover Building Management System as described below and on the drawings.

PART 2 - PRODUCTS

2.1 MANUFACTURER
A. All products used in this project shall be furnished and installed by the existing campus BMS Vendor, Entech Sales thru the existing purchasing agreement, no substitutions.

2.2 COMMUNICATION
A. All control products provided for this project shall comprise a BACnet network. Communication involving control components (i.e., all types of controllers and Operators Workstations) shall conform to ANSI/ASHRAE Standard 135-2001, BACnet.

2.3 OPERATOR WORKSTATIONS
A. The existing PC-based operator workstation shall be retained. This workstation shall reside on the same Ethernet protocol network as the Building Control.
B. Andover shall upgrade the hardware and software as required for the control of this additional equipment.

2.4 CONTROLLER SOFTWARE.
A. Furnish application specific software for building and energy management. All software applications shall reside and operate in the system controllers. Editing of applications shall occur at the operator workstation. The software shall include, but is not necessarily limited to, scheduling, alarm reporting, remote communication, maintenance management, sequencing, staggered start, energy calculations, anti-short cycling, on/off control, and run totalization.
2.5 AIR TERMINAL CONTROL

A. All air terminals, both VAV and FPB, shall be controlled by the Andover control system. Terminal controllers shall be supplied to the terminal unit manufacturer by Andover for factory mounting.

B. The terminal unit control shall employ a “Dual Maximum Logic” as required by ASHRAE 90.1, Addendum CK. Reference Section 23 36 00 for the sequence of operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The project plans shall be thoroughly examined for control devices and equipment locations. Any discrepancies, conflicts or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started.

B. Systems to be connected to this BAS are shown on the drawings and described in the Sequence of Operation in Section 233600 and 237313.

C. Where the mechanical work will be installed in close proximity to, or will interfere with work of other trades, the Contractor shall assist in working out space conditions to make a satisfactory adjustment. If the Contractor installs its work before coordinating with other trades so as to cause any interference with work of other trades, the Contractor shall make the necessary changes in its work to correct the condition without extra charge.

D. Start-up Testing: All testing listed in this article shall be performed by the Contractor and shall make up part of the necessary verification of an operating control system. This testing shall be completed before the Owner’s Representative is notified of the system demonstration.

E. Demonstration: Prior to acceptance, the control system shall undergo a series of performance tests to verify operation and compliance with this specification. These tests shall occur after the Contractor has completed the installation, start up and commissioning of the system.

F. Training: Provide a minimum of two on-site training class four hours in length following building’s turnover. At six months, provide an additional on-site training class of four hours at a time to be coordinated with the building Owner.

PART 4 – SEQUENCES OF OPERATION

4.1 COORDINATION

A. Following are the sequences of operation for the various HVAC equipment. Coordinate with the points lists shown and the control schematics on the drawings for a complete system.
AIR-HANDLING-UNIT CONTROL SEQUENCES (Typical for RTU-1 and 2 as applicable)

A. Start and Stop Supply & Relief Fan(s):

1. Enable: Freeze Protection:
   a. Input Device: Duct-mounted averaging element thermostat, located before supply fan.
   b. Output Device: Hard wired through motor starter; BMS system alarm.
   c. Action: Allow start if duct temperature is above 37 deg F (3 deg C); signal alarm if fan fails to start as commanded.

2. Enable: High-Temperature Protection:
   a. Input Device: Duct-mounted thermostat, located in return air.
   b. Output Device: Hard wired through motor starter; BMS system alarm.
   c. Action: Allow start if duct temperature is below 300 deg F (150 deg C).

3. Enable: Smoke Control:
   a. Input Device: Duct-mounted smoke detector, located in return and supply air.
   b. Output Device: Hard wired through motor starter; BMS system alarm.
   c. Action: Allow start if duct is free of products of combustion.

4. Initiate: Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: Binary output to motor starter.
   c. Action: Energize fan(s).

5. Initiate: Unoccupied Time Schedule:
   a. Input Device: BMS system demand.
   b. Output Device: Binary output to motor starter.
   c. Action: Energize fan(s).

6. Unoccupied Ventilation:
   a. Input Device: BMS system time schedule and output.
   b. Output Device: BMS system binary output to motor starter.
   c. Action: Cycle fan(s) during unoccupied periods.


B. Supply & Relief Fan(s) Variable-Volume Control:

1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   c. Action: Enable control.
2. Volume Control:
   a. Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to conditioned-space static pressure.
   b. Output Device: Receiver controller to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
   c. Action: Maintain constant supply-duct static pressure. Reset static pressure down while maintaining space temperature in the zone requiring the most cooling with the VAV or FPB at 95% open.

3. High Pressure:
   a. Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
   b. Output Device: BMS system binary output to motor starter.
   c. Action: Stop fan and signal alarm when static pressure rises above excessive-static-pressure set point.

4. Display:
   a. Supply-fan-discharge static-pressure indication.
   b. Supply-fan-discharge static-pressure set point.
   c. Supply-fan airflow rate.
   d. Supply-fan speed.
   e. Relief-fan airflow rate.
   f. Relief-fan speed.

C. Preheat Coil

1. Freeze Protection:
   a. Input Device: Duct-mounted averaging element thermostat, located after preheat coil.
   b. Output Device: Hard wired through motor starter; BMS system alarm.
   c. Action: Allow start if duct temperature is above 33 deg F (1 deg C).

2. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: Binary output to motor starter.
   c. Action: Stage coil on/off.

3. Supply Discharge-Air Temperature:
   a. Input Device: Time clock and duct-mounted thermostat DDC system time schedule and electronic temperature sensor.
   b. Output Device: Modulating control valve.
   c. Action: Maintain air temperature set point of 55 deg F (13 deg C).

4. Unoccupied Time Schedule:
a. Input Device: BMS system time schedule and outdoor-air temperature.
b. Output Device: Binary output to motor starter.
c. Action: AHU to remain off.

5. Display:
   a. Preheat-coil air-temperature indication.
   b. Preheat-coil air-temperature set point.
   c. Preheat-coil SCR position.

D. Mixed-Air Control:

1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system output.
   c. Action: Enable control.

2. Minimum Position:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system analog output to modulating damper actuator(s).
   c. Action: Open outdoor-air dampers to minimum position.

3. Heating Reset:
   a. Input Device: BMS system software.
   b. Output Device: BMS system analog output to modulating damper actuator(s).
   c. Action: Set outdoor-air dampers to minimum position.

4. Cooling Reset:
   b. Output Device: BMS system analog output to damper actuator(s).
   c. Action: Set outdoor-air dampers to minimum position when outdoor-air enthalpy exceeds return-air enthalpy.

5. Unoccupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system analog output to modulating damper actuator(s).
   c. Action: Position outdoor- and relief-air dampers closed and return-air dampers open.

6. Display:
   b. Mixed-air-temperature set point.
   c. Mixed-air damper position.
E. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.

1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system output.
   c. Action: Enable control.

2. Differential Pressure:
   a. Input Device: Pressure transmitter.
   b. Output Device: BMS system alarm.
   c. Action: Signal alarm on low- and high-pressure conditions.

3. Display:
   a. Filter air-pressure-drop indication.
   b. Filter low-air-pressure set point.
   c. Filter high-air-pressure set point.

F. Hydronic Cooling Coil

1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   c. Action: Enable control.

2. Discharge-Air Temperature:
   b. Output Device: Normally closed modulating control valve.
   c. Action: Maintain supply-air temperature set point of 55 deg F (13 deg C).

3. Temperature Reset:
   a. Input Device: Electronic temperature sensor in return air.
   b. Output Device: BMS system in straight-line relationship for the following conditions:
      1) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
      2) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).
   c. Action: Reset supply-air temperature set point of 55 deg F (13 deg C).

4. Unoccupied Time Schedule:
   a. Input Device: BMS system time schedule.
   c. Action: Disable control.
5. Display:
   a. Fan-discharge air-temperature indication.
   b. Fan-discharge air-temperature set point.
   c. Cooling-coil air-temperature indication.
   d. Cooling-coil air-temperature set point.
   e. Cooling-coil control-valve position.
   f. Cold-deck air-temperature indication.
   g. Cold-deck air-temperature set point.

G. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

H. Operator Station Display: Indicate the following on operator workstation display terminal:
   1. BMS system graphic.
   2. BMS system on-off indication.
   3. BMS system occupied/unoccupied mode.
   5. Supply-fan on-off indication.
   7. Supply-fan-discharge static-pressure set point.
  10. Return-air static-pressure indication.
  11. Return-air static-pressure set point.
  15. Preheat-coil air-temperature set point.
  17. Mixed-air-temperature set point.
  18. Mixed-air damper position.
  20. Filter air-pressure-drop indication.
  22. Filter high-air-pressure set point.
  23. Cooling-coil air-temperature indication.
  24. Cooling-coil air-temperature set point.
  25. Cooling-coil control-valve position.
  26. Room temperature indication.
  27. Room temperature set point.

4.3 AIR-HANDLING-UNIT CONTROL SEQUENCES (Typical for RTU-3)

A. RTU-3 shall operate same as that described above for RTU-1 and 2, except that it is a variable single zone system.

B. Start and Stop Supply & Relief Fan(s):
   1. Enable: Freeze Protection:
a. Input Device: Duct-mounted averaging element thermostat, located before supply fan.
b. Output Device: Hard wired through motor starter; BMS system alarm.
c. Action: Allow start if duct temperature is above 37 deg F (3 deg C); signal alarm if fan fails to start as commanded.

2. Enable: High-Temperature Protection:

a. Input Device: Duct-mounted thermostat, located in return air.
b. Output Device: Hard wired through motor starter; BMS system alarm.
c. Action: Allow start if duct temperature is below 300 deg F (150 deg C).

3. Enable: Smoke Control:

a. Input Device: Duct-mounted smoke detector, located in return and supply air.
b. Output Device: Hard wired through motor starter; BMS system alarm.
c. Action: Allow start if duct is free of products of combustion.

4. Initiate: Occupied Time Schedule:

a. Input Device: BMS system time schedule.
b. Output Device: Binary output to motor starter.
c. Action: Energize fan(s).

5. Initiate: Unoccupied Time Schedule:

a. Input Device: BMS system demand.
b. Output Device: Binary output to motor starter.
c. Action: Energize fan(s).

6. Unoccupied Ventilation:

a. Input Device: BMS system time schedule and output.
b. Output Device: BMS system binary output to motor starter.
c. Action: Cycle fan(s) during unoccupied periods.


C. Supply & Relief Fan(s) Variable-Volume Control:

1. Occupied Time Schedule:

a. Input Device: BMS system time schedule.
c. Action: Enable control.

2. Volume Control:

a. Input Device: Space temperature sensor.
b. Output Device: Receiver controller to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
c. Action: Modulate fan speed down to a minimum of 50% (adj.) airflow based on space temperature, while modulating the chilled water valve to maintain a constant discharge temperature of 55°F (adj.). Upon a further drop in space temperature, reset the discharge temperature up to a maximum of 65°F (adj.). Upon a further drop in space temperature, energize the heating coil and modulate the heat output thru the SCR controller.

3. Display:
   a. Supply-fan-discharge static-pressure indication.
   b. Supply-fan-discharge static-pressure set point.
   c. Supply-fan airflow rate.
   d. Supply-fan speed.
   e. Relief fan airflow.
   f. Relief fan speed.

C. Preheat Coil

4. Freeze Protection:
   a. Input Device: Duct-mounted averaging element thermostat, located after preheat coil.
   b. Output Device: Hard wired through motor starter; BMS system alarm.
   c. Action: Allow start if duct temperature is above 33 deg F (1 deg C).

5. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: Binary output to motor starter.
   c. Action: Stage coil on/off.

6. Supply Discharge-Air Temperature:
   a. Input Device: Time clock and duct-mounted thermostat DDC system time schedule and electronic temperature sensor.
   b. Output Device: Modulating control valve.
   c. Action: Maintain air temperature set point of 55 deg F (13 deg C).

7. Unoccupied Time Schedule:
   a. Input Device: BMS system time schedule and outdoor-air temperature.
   b. Output Device: Binary output to motor starter.
   c. Action: AHU to remain off.

8. Display:
   a. Preheat-coil air-temperature indication.
   b. Preheat-coil air-temperature set point.
   c. Preheat-coil SCR position.

D. Mixed-Air Control:
1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system output.
   c. Action: Enable control.

2. Minimum Position:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system analog output to modulating damper actuator(s).
   c. Action: Open outdoor-air dampers to minimum position.

3. Heating Reset:
   a. Input Device: BMS system software.
   b. Output Device: BMS system analog output to modulating damper actuator(s).
   c. Action: Set outdoor-air dampers to minimum position.

4. Cooling Reset:
   b. Output Device: BMS system analog output to damper actuator(s).
   c. Action: Set outdoor-air dampers to minimum position when outdoor-air enthalpy exceeds return-air enthalpy.

5. Unoccupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system analog output to modulating damper actuator(s).
   c. Action: Position outdoor- and relief-air dampers closed and return-air dampers open.

6. Display:
   b. Mixed-air-temperature set point.
   c. Mixed-air damper position.

E. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.

1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   b. Output Device: BMS system output.
   c. Action: Enable control.

2. Differential Pressure:
   a. Input Device: Pressure transmitter.
b. Output Device: BMS system alarm.
c. Action: Signal alarm on low- and high-pressure conditions.

3. Display:
   a. Filter air-pressure-drop indication.
   b. Filter low-air-pressure set point.
   c. Filter high-air-pressure set point.

F. Hydronic Cooling Coil

1. Occupied Time Schedule:
   a. Input Device: BMS system time schedule.
   c. Action: Enable control.

2. Discharge-Air Temperature:
   b. Output Device: Normally closed modulating control valve.
   c. Action: Maintain supply-air temperature set point of 55 deg F (13 deg C).

3. Temperature Reset:
   a. Input Device: BMS system with input from room temperature sensors.
   b. Output Device: BMS system.
   c. Action: Reset supply-air temperature in response to space temperature as noted above under “Volume Control”.

4. Unoccupied Time Schedule:
   a. Input Device: BMS system time schedule.
   c. Action: Disable control.

5. Display:
   a. Fan-discharge air-temperature indication.
   b. Fan-discharge air-temperature set point.
   c. Cooling-coil air-temperature indication.
   d. Cooling-coil air-temperature set point.
   e. Cooling-coil control-valve position.
   f. Cold-deck air-temperature indication.
   g. Cold-deck air-temperature set point.

G. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.

H. Operator Station Display: Indicate the following on operator workstation display terminal:
1. BMS system graphic.
2. BMS system on-off indication.
3. BMS system occupied/unoccupied mode.
5. Supply-fan on-off indication.
7. Supply-fan airflow rate.
9. Return-air static-pressure indication.
13. Preheat-coil air-temperature set point.
15. Mixed-air-temperature set point.
17. Relative humidity indication.
18. Filter air-pressure-drop indication.
19. Filter low-air-pressure set point.
20. Filter high-air-pressure set point.
22. Cooling-coil air-temperature set point.
23. Cooling-coil control-valve position.
24. Room temperature indication.
25. Room temperature set point.

4.4 EXHAUST FANS

A. Exhaust fan EF-1 shall be interlocked to run whenever RTU-1, RTU-2, or RTU-3 is operating. EF-2 shall operate continuously, 24/7.

1. Provide the following alarms:
   a. Fan Failure: Commanded on but the status is off.
   b. Fan in Hand: Commanded off but the status is on.

4.5 DX AIR CONDITIONING UNITS (Typical for AC-1, AC-2, AC-3, AC-4)

A. The AC units shall be enabled to operate 24/7. The indoor evaporator fan and associated condensing unit shall cycle as need to maintain the room setpoint temperature.

B. In addition, units AC-2 and AC-3 shall operate in a lead/lag fashion. With the lead unit operating and the space temperature rising 2°F above the setpoint for 10 minutes, the lag unit shall be energized, and shall operate until the space temperature drops 2°F below the setpoint. The lead and lag units shall be rotated on a weekly basis.

1. Provide the following alarms:
   a. High space temperature.
   b. Water in the condensate pan.
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. This Section includes pipe and fitting materials, joining methods, special-duty valves, and
   specialties for the following:
   1. Chilled-water piping.
   2. Makeup-water piping.
   3. Condensate-drain piping.

B. Related Sections include the following:
   1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic
      piping.

1.3 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

B. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

C. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following
   minimum working pressure and temperature:
   1. Chilled-Water Piping: 150 psig at 200 deg F.
   2. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
   4. Air-Vent Piping: 80 psig at 150 deg F.
1.5 SUBMITTALS

A. Product Data: For each type of the following:
   1. Pressure-seal fittings.
   2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
   3. Air control devices.
   5. Hydronic specialties.

B. Welding certificates.

C. Qualification Data: For Installer.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

F. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.6 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
   1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
   2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.7 EXTRA MATERIALS

A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.

B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.
PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L (ASTM B 88M, Type B).

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Wrought-Copper Fittings: ASME B16.22.

   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. Anvil International, Inc.
      b. S. P. Fittings; a division of Star Pipe Products.
      c. Victaulic Company of America.

2. Grooved-End Copper Fittings: ASTM B 75 (ASTM B 75M), 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 (110 deg C) for use with housing, and steel bolts and nuts.

E. Copper or Bronze Pressure-Seal Fittings:

   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. Viega.

2. Housing: Copper.

3. O-Rings and Pipe Stops: EPDM.

4. Tools: Manufacturer's special tools.

5. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).

F. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Stainless Steel Pipe: ASTM A312, Type 304/304L schedule 10S with plain ends.

C. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

E. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

F. 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 Part 3 "Piping Applications" Article.

G. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

H. 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:
   2. End Connections: Butt welding.
   3. Facings: Raised face.

I. Grooved Mechanical-Joint Fittings and Couplings:
   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. Anvil International, Inc.
      b. Central Sprinkler Company; a division of Tyco Fire & Building Products.
      c. National Fittings, Inc.
      d. S. P. Fittings; a division of Star Pipe Products.
      e. Victaulic Company of America.
   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, 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 synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

J. Steel Pressure-Seal Fittings:
   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. Victaulic Company of America.
   2. Housing: Steel.
   3. O-Rings and Pipe Stop: EPDM.
   4. Tools: Manufacturer’s special tool.
   5. Minimum 300-psig (2070-kPa) working-pressure rating at 230 deg F (110 deg C).

K. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.
2.3 POLYPROPYLENE PIPE AND FITTINGS

A. Pipe and fittings shall be manufactured of a PP-R resin (Fusiolen) meeting the short-term properties and long-term strength requirements of ASTM F 2389 or CSA B137.11. The pipe shall contain no rework or recycled materials except that generated in the manufacturer’s own plant from resin of the same specification from the same raw material. All pipe shall be made in an extrusion process. Hydronic hot water and heating piping shall contain a fiber layer (faser) to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F 2389 or CSA B137.11. All pipe shall be certified by NSF International as complying with NSF 14, and ASTM F 2389 or CSA B137.11.

B. Pipe and fitting shall be Aquatherm® Green Pipe® MF® or Blue Pipe® MF®, available from Aquatherm, NA. Piping and fitting specifications and ordering information are available at www.aquatherm.com.

C. Underground piping shall be double wall, pre insulated consisting of PEX carrier pipe, PEX-foam insulation, and a corrugated water tight HDPE outer jacket. Pipe shall be “EcoFlex Thermal Single” as manufactured by Wirsbo.

2.4 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.
   a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
   b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions:
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:
   b. Central Plastics Company.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division.

2. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

D. Dielectric Flanges:

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:
   b. Central Plastics Company.
   c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

E. Dielectric-Flange 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. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

F. Dielectric Couplings:

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. Calpico, Inc.
   b. Lochinvar Corporation.

2. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).
G. Dielectric Nipples:

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. Perfection Corporation; a subsidiary of American Meter Company.
   b. Precision Plumbing Products, Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Victaulic Company of America.

2. Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

2.6 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping." Valves for installation in PP-12 piping systems shall be as manufactured by the pipe manufacture.

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

C. Diaphragm-Operated, Pressure-Reducing 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. Amtrol, Inc.
   b. Armstrong Pumps, Inc.
   c. Bell & Gossett Domestic Pump; a division of ITT Industries.
   d. Conbraco Industries, Inc.
   e. Spence Engineering Company, Inc.
   f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
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. Automatic Flow-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. Flow Design Inc.
   b. Griswold Controls.

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.

2.7 AIR CONTROL DEVICES

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/4 (DN 8).
6. CWP Rating: 150 psig (1035 kPa).

2.8 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: [40] [60]-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.

B. Stainless-Steel Bellow, Flexible Connectors:
   2. End Connections: Threaded or flanged to match equipment connected.
   3. Performance: Capable of 3/4-inch (20-mm) misalignment.
   4. CWP Rating: 150 psig (1035 kPa).
   5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be any of the following:
   1. Type L drawn-temper copper tubing, wrought-copper fittings, and brazed pressure-seal joints.
   2. Schedule 40 steel pipe; Class 150, malleable-iron, fittings; cast-iron flanges and flange fittings; and threaded joints.
   3. Schedule 10S stainless steel pipe; steel, pressure-seal couplings and fittings; and pressure-seal joints.
   4. Polypropylene pressure pipe, fittings and valves as manufactured by Aquatherm or Uponor (Wirsbo HePEX).

B. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be the following:
   1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings; and welded and flanged joints. This shall be the base bid.
   2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints can be bid as an alternate, bid separately.
   3. Polypropylene pressure pipe, fittings and valves as manufactured by Aquatherm or Uponor (Wirsbo HePEX).

C. Chilled-water piping, underground, all sizes, shall be Uponor “Ecoflex” pre-insulated piping system consisting of a pex-a carrier pipe, multi-layer PEX foam insulation, covered by a watertight corrugated HDPE jacket.

D. Makeup-water piping installed aboveground shall be the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

E. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

F. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

G. Air-Vent Piping:
1. Inlet: Same as service where installed.
2. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
B. Install automatic flow control valves in the return pipe of each heating or cooling terminal.
C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
E. Install piping to permit valve servicing.
F. Install piping at indicated slopes.
G. Install piping free of sags and bends.
H. Install fittings for changes in direction and branch connections.
I. Install piping to allow application of insulation.
J. Select system components with pressure rating equal to or greater than system operating pressure.
K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
O. Install branch connections to mains using [mechanically formed] tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

T. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

D. Install hangers for schedule 40 steel piping with the following maximum spacing and minimum rod sizes or as shown on the drawings:

1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
E. Install hangers for drawn-temper copper piping or schedule 105 steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).

F. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA’s “Copper Tube Handbook,” using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS’s “Brazing Handbook,” “Pipe and Tube” Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.


H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. 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 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.8 FIELD QUALITY CONTROL

A. 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.

Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:

1. Chilled-Water Piping: Minimum 20 percent propylene glycol.

B. 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.

C. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

D. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13
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 ducts and fittings.
   4. Duct liner.
   5. Sealants and gaskets.
   6. Hangers and supports.
B. Related Sections:
   1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting,
      and balancing requirements for metal ducts.
   2. Division 23 Section "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

1.4 SUBMITTALS
A. Product Data: For each type of the following products:
   1. Liners and adhesives.
   2. Sealants and gaskets.
B. 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, and vibration isolation.

C. 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. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

D. Welding certificates.

E. Field quality-control reports.

1.5 QUALITY ASSURANCE


B. Welding Qualifications: Qualify procedures and personnel according to the following:

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.4.4 - "HVAC System Construction and Insulation."
PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) 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 1-5, "Longitudinal Seams - Rectangular Ducts," 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 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   a. Lindab Inc.
   b. McGill AirFlow LLC.
   c. SEMCO Incorporated.
   d. Sheet Metal Connectors, Inc.
   e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," 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 (1524 mm) in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G60 (Z180).
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated on the drawings; cold rolled, annealed, sheet.

E. 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.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.4 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. CertainTeed Corporation; Insulation Group.
      b. Johns Manville.
      c. Knauf Insulation.
      d. Owens Corning.
      e. Maximum Thermal Conductivity:
1) Type I, Flexible: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
2) Type II, Rigid: 0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K) at 75 deg F (24 deg C) 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-Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
   a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.
   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:
   2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:
      a. Bonded Logic, Inc.
      b. Reflectix Inc.
   3. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature when tested according to ASTM C 518.
   4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
   5. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
      a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Insulation Pins and Washers:
   1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
   2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized steel with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "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 (12.7 m/s).
7. Secure liner with mechanical fasteners 4 inches (100 mm) from corners and at intervals not exceeding 12 inches (300 mm) transversely; at 3 inches (75 mm) from transverse joints and at intervals not exceeding 18 inches (450 mm) 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 (12.7 m/s) or where indicated.
9. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
   a. Sheet Metal Inner Duct Perforations: 3/32-inch (2.4-mm) diameter, with an overall open area of 23 percent.
10. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.5 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
   1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
   2. Tape Width: 4 inches (102 mm).
   5. Mold and mildew resistant.
   6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   7. Service: Indoor and outdoor.
   8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
   10. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
C. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.
   5. Mold and mildew resistant.
   6. VOC: Maximum 75 g/L (less water).
   7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
   8. Service: Indoor or outdoor.
   9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Base: Synthetic rubber resin.
   4. Solids Content: Minimum 60 percent.
   5. Shore A Hardness: Minimum 60.
   7. Mold and mildew resistant.
   8. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
   9. VOC: Maximum 395 g/L.
   10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
   11. Service: Indoor or outdoor.
   12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.
   2. Type: S.
   3. Grade: NS.
   5. Use: O.
   6. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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 (0.14 L/s per sq. m at 250 Pa) and shall be rated for 10-inch wg (2500-Pa) static-pressure class, positive or negative.
   2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
   3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "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:
   3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
3. Unconditioned Space, Exhaust Ducts: Seal Class C.
4. Unconditioned Space, Return-Air Ducts: Seal Class B.
5. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
6. Conditioned Space, Exhaust Ducts: Seal Class B.
7. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.6 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 Division 09 painting Sections.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

2. Test the following systems:
   a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative.
   b. Supply Ducts with a Pressure Class of 2-Inch wg (500 Pa) or Less: Test representative duct sections, selected by Engineer from sections installed, totaling
no less than 25 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days’ advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to “Vacuum Test” in NADCA ACR, “Assessment, Cleaning and Restoration of HVAC Systems.”
   a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.8 DUCT CLEANING

A. Clean 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 Division 23 Section “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.


5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.


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.

3.9 START UP

A. Air Balance: Comply with requirements in Division 23 Section “Testing, Adjusting, and Balancing for HVAC.”

3.10 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Heat Pumps, and Terminal Units.
   
   a. Pressure Class: Positive 1-inch wg (250 Pa).
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round 6.

2. Ducts Connected to Variable-Air-Volume Air-Handling Units <Insert equipment>:

   a. Pressure Class: Positive 2-inch wg (750 Pa).
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round 3.
C. Return Ducts:

1. Ducts Connected to Air-Handling Units.
   a. Pressure Class: Positive or negative 2-inch wg (500 Pa).
   b. Minimum SMACNA Seal Class: B.
   c. SMACNA Leakage Class for Rectangular: 8.
   d. SMACNA Leakage Class for Round 4.

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 1-inch wg (250 Pa).
   b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 12.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Intermediate Reinforcement:

Galvanized-Steel Ducts: Galvanized steel.

F. Liner:

1. Supply Air Ducts: Fibrous glass, Type I or Natural fiber, 1 inch (25 mm thick).
2. Return Air Ducts: Fibrous glass, Type I or Natural fiber, 1 inch (25 mm) thick.
3. Transfer Ducts: Fibrous glass, Type I or Natural fiber, 1 inch (25 mm) thick.

G. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
   a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
   b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
   c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."

2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
   a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
      1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
      2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      4) Radius-to Diameter Ratio: 1.5.
b. Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam.

H. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
   a. Rectangular Main to Rectangular Branch: 45-degree entry.
   b. Rectangular Main to Round Branch: 45-degree or bellmouth entry.

2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees."
   a. Velocity 1500 fpm or less: Conical tap.
   b. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113
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.
3. Control dampers.
4. Fire dampers.
5. Smoke dampers.
6. Combination fire and smoke dampers.
7. Turning vanes.
8. Duct-mounted access doors.
10. Flexible ducts.
11. Duct accessory hardware.

B. Related Sections:

1. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.3 SUBMITTALS

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

B. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

   a. Special fittings.
   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.
C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE


B. Comply with AMCA 500-D testing for damper rating.

1.5 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed, minimum of 6.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

   1. Galvanized Coating Designation: G60 (Z180).
   2. Exposed-Surface Finish: Mill phosphatized.

C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

D. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.2 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

      a. Air Balance Inc.; a division of Mestek, Inc.
      b. American Warming and Ventilating; a division of Mestek, Inc.
      c. Flexmaster U.S.A., Inc.
      d. McGill AirFlow LLC.
      e. METALAIRE, Inc.
      f. Nailor Industries Inc.
g. Pottorff; a division of PCI Industries, Inc.
h. Ruskin Company.
i. Trox USA Inc.
j. Vent Products Company, Inc.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:
   a. Hat-shaped, galvanized-steel channels, 0.064-inch (1.62-mm) minimum thickness.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 0.064 inch (1.62 mm) thick.

7. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

2.3 FIRE DAMPERS

A. 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. Air Balance Inc.; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
5. McGill AirFlow LLC.
6. METALAIRE, Inc.
7. Nailor Industries Inc.
8. NCA Manufacturing, Inc.
9. PHL, Inc.
10. Pottorff; a division of PCI Industries, Inc.
11. Prefco; Perfect Air Control, Inc.
12. Ruskin Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.

D. Fire Rating: 1-1/2 hours.
E. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-(0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: 0.052 or 0.138 inch (1.3 or 3.5 mm) 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- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

2.4 SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
4. Nailor Industries Inc.
5. PHL, Inc.
6. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Remote part of the Fire Alarm system specified in Division 28.

D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

E. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.

F. Leakage: Class I.

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

I. Damper Motors: Two-position action.
J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control 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 (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
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 (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).

K. Accessories:

1. Auxiliary switches for signaling, fan control, or position indication.
2. Momentary test switch, damper mounted.

2.5 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
4. Nailor Industries Inc.
5. Ruskin Company.

B. Type: Static and dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to 4-inch wg (1-kPa) static pressure class and minimum 4000-fpm (20-m/s) velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

F. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) rated, fusible links.

G. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
H. Leakage: Class I.

I. Rated pressure and velocity to exceed design airflow conditions.

J. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.

K. Damper Motors: Two-position action.

L. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

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

2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section "Instrumentation and Control 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 (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

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 (minus 40 deg C).

6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).


M. Accessories:

1. Auxiliary switches for signaling, fan control, or position indication.

2. Momentary test switch, damper mounted.

2.6 TURNING VANES

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

1. Ductmate Industries, Inc.

2. Duro Dyn Inc.

3. METALAIRE, Inc.

4. SEMCO Incorporated.


B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible”; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Double wall.
2.7  DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
5. Greenheck Fan Corporation.
6. McGill AirFlow LLC.
7. Nailor Industries Inc.
8. Pottorff; a division of PCI Industries, Inc.
9. Ventfabrics, Inc.


1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Hinges and Latches: 1-by-1-inch (25-by-25-mm) butt or piano hinge and cam latches.
   d. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches (460 mm) Square: Two hinges and two sash locks.
   c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Three hinges and two compression latches.
   d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Four hinges and two compression latches with outside and inside handles.

2.8  FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Ventfabrics, Inc.

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 (89 mm) wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

   1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
   2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
   3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

2.9 FLEXIBLE DUCTS

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. Flexmaster U.S.A., Inc.
   2. McGill AirFlow LLC.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor-barrier film.
   1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
   2. Maximum Air Velocity: 4000 fpm (20 m/s).
   3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
   4. Insulation R-value: Comply with ASHRAE/IESNA 90.1-2004 or IECC 2012, whichever is greater.

C. Flexible Duct Connectors:
   1. Clamps: Nylon strap in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.

2.10 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA’s "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install backdraft or control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install test holes at fan inlets and outlets and elsewhere as indicated.

F. Install fire and smoke dampers according to UL listing.

G. Install duct security bars. Construct duct security bars from 0.164-inch (4.18-mm) steel sleeve, continuously welded at all joints and 1/2-inch- (13-mm-) diameter steel bars, 6 inches (150 mm) o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) hinged access panel with cam lock in duct in each side of sleeve.

H. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

   1. On both sides of duct coils.
   2. At outdoor-air intakes and mixed-air plenums.
   3. At drain pans and seals.
   4. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
   5. 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.
   6. Control devices requiring inspection.
   7. Elsewhere as indicated.

I. Install access doors with swing against duct static pressure.

J. Access Door Sizes:

   1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
   2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
   3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
   4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).

K. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

L. Install flexible connectors to connect ducts to equipment.

M. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

N. Connect terminal units to supply ducts directly or with maximum 12-inch (300-mm) lengths of flexible duct. Do not use flexible ducts to change directions.
O. Connect diffusers or light troffer boots to ducts with maximum 60-inch (1500-mm) lengths of flexible duct clamped or strapped in place.

P. Connect flexible ducts to metal ducts with draw bands.

Q. Install duct test holes where required for testing and balancing purposes.

R. 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 (6-mm) movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00
SECTION 23 34 23

HVAC FANS

PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following:

1. Centrifugal roof ventilators.
2. Centrifugal cabinet 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: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.


C. Field quality-control test reports.

D. 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, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.8 EXTRA MATERIALS

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

1. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

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

2. Captive Aire
4. Loren Cook Company.
5. Penn Ventilation.
B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories. Entire fan and curb assembly shall be seismic and hurricane rated.

C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
4. Fan and motor isolated from exhaust airstream.

F. Motors:

1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
2. Enclosure Type: Open drip-proof, mounted out of the airstream.

G. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
3. Dampers: As scheduled, counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Grease cups (where scheduled).

H. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange.
2. Overall Height: 12 inches (300 mm).
4. Ventilated extended curbs, where scheduled.

2.2 CENTRIFUGAL CABINET FANS

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

1. Breidert Air Products.
3. Carnes Company HVAC
5. Loren Cook Company
6. Penn Ventilation.

B. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.

C. Housing: Steel, lined with acoustical insulation.

D. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 10 to less than 50 percent.
4. Manufacturer's standard roof jack or wall cap, and transition fittings.

2.2 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.

C. Install units with clearances for service and maintenance.

D. 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 Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.
SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Fan-powered air terminal units.
2. Shutoff single-duct air terminal units.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.4 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

D. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

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

2.2 FAN-POWERED AIR TERMINAL UNITS

A. Manufacturers:

2. Krueger.
3. METALAIRE, Inc.; Metal Industries Inc.
4. Nailor Industries of Texas Inc.
5. Price Industries.
6. Titus.
7. Trane Co. (The).

B. Configuration: Volume-damper assembly and fan in series or in parallel arrangement, as indicated on Drawings, inside unit casing with control components inside a protective metal shroud.

C. Casing: 0.034-inch (0.85-mm) steel.

1. Casing Lining: 1/2-inch- (13-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive.
2. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections.
4. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.

E. Fan Section: Galvanized-steel plenum, with direct-drive, forward-curved fan with air filter and backdraft damper.
   1. Motor: ECM. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
      a. Speed Control: Infinitely adjustable with pneumatic-electric and electronic controls.
      b. Fan-Motor Assembly Isolation: Rubber isolators.
   2. Air Filter: 2-inch- (50-mm-) thick, MERV 7 according to ASHRAE 52.2.

F. Electric Heating Coil: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:
   1. Primary and secondary overtemperature protection.
   2. Nickel chrome 80/20 heating elements.
   3. Airflow switch.
   5. Fuses (for coils more than 48 A).
   7. Magnetic contactor for each step of control (for three-phase coils).

G. Factory-Mounted and -Wired Controls: Electrical components shall be mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
   1. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
   2. Wiring Terminations: Fan and controls to terminal strip, and terminal lugs shall match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
   3. Disconnect Switch: Factory-mounted, fused type.

H. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.

I. DDC Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor shall be compatible with the existing Andover building Management System. The controllers shall be supplied by the campus BMS vendor to the manufacturer for factory mounting and testing, and shall have the following features:
   1. Proportional, plus integral control of room temperature.
   2. Time-proportional reheat-coil control.
   3. Occupied and unoccupied operating mode.
   4. Remote reset of airflow or temperature set points.
   5. Adjusting and monitoring with portable terminal.
   6. Communication with Andover temperature-control system.

J. Room Sensor: Wall mounting, with temperature set-point adjustment and access for connection of portable operator terminal.
K. Control Sequence:

1. With central system fan operating in occupied mode, sequence the controls as follows:
   a. With space temperature above the cooling setpoint, modulate volume damper to proportion airflow from central system.
   b. On reduced-cooling demand, close volume damper.
   c. With volume damper at minimum settings and a further drop in space temperature, energize fan.
   d. Speed control adjusts air terminal fan speed to match downstream resistance.
   e. With full fan speed and a further drop in space temperature, energize heating coil.

2. With central system fan operating in unoccupied mode, sequence the controls as follows:
   a. Cycle air terminal fan to maintain set-back room temperature.

2.3 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers:

2. Krueger.
3. METALAIRE, Inc.; Metal Industries Inc.
4. Nailor Industries of Texas Inc.
5. Price Industries.
6. Titus.
7. Trane Co. (The).

B. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

C. Casing: 0.034-inch (0.85-mm) steel.

1. Casing Lining: 1/2-inch- (13-mm-) thick, coated, fibrous-glass duct liner complying with ASTM C 1071; secured with adhesive.
2. Casing Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
3. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
5. Access: Removable panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket.

D. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
E. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg (750-Pa) inlet static pressure.

F. Electric Heating Coil: Slip-in-type, open-coil design with integral control box factory wired and installed. Include the following features:

1. Primary and secondary overtemperature protection.
2. Nickel chrome 80/20 heating elements.
3. Airflow switch.
5. Fuses (for coils more than 48 A).
7. Magnetic contactor for each step of control (for three-phase coils).

G. DDC Controls: Bidirectional damper operators and microprocessor-based controller and room sensor shall be compatible with the existing JCI/MetaSys Building Management System. The controllers shall be furnished by JCI to the manufacturer for factory mounting and testing, and shall have the following features:

1. Damper Actuator: 24 V, powered closed, powered open.
2. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
   a. Proportional, plus integral control of room temperature.
   b. Time-proportional reheat-coil control.
   c. Occupied and unoccupied operating mode.
   d. Remote reset of airflow or temperature set points.
   e. Adjusting and monitoring with portable terminal.
   f. Communication with temperature-control system specified in Division 23 Section "Instrumentation and Control for HVAC."
3. Room Sensor: Wall mounting, with temperature set-point adjustment and access for connection of portable operator terminal.

H. Control Sequence:

1. With central system fan operating in occupied mode, sequence the controls as follows:
   a. With space temperature above the cooling setpoint, modulate volume damper to proportion airflow from central system.
   b. On reduced-cooling demand, modulate volume damper to the minimum position.
   c. With volume damper at minimum setting and a further drop in temperature, energize heating coil, when equipped.
2. With central system fan operating in unoccupied mode, air terminal damper shall be closed.
2.4 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air terminal units to allow service and maintenance.

C. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts."

D. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
C. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions and do the following:

   a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
   b. Verify that controls and control enclosure are accessible.
   c. Verify that control connections are complete.
   d. Verify that nameplate and identification tag are visible.
   e. Verify that controls respond to inputs as specified.

3.5 DEMONSTRATION

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

END OF SECTION 23 36 00
SECTION 23 37 13

AIR 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. Rectangular, round and square ceiling diffusers.
2. Return grilles.
3. Louver face diffusers.
4. Linear slot diffusers.
5. Adjustable bar grilles.
6. Fixed face registers.
7. Wall louvers.

B. Related Sections:

1. 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, Grille and Louver Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Rectangular, Round 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:

b. Krueger.
c. METALAIRE, Inc.
d. Nailor Industries Inc.
e. Price Industries.
f. Titus.
g. Tuttle & Bailey.

2. Devices shall be specifically designed for variable-air-volume flows.
4. Finish: Baked enamel, white.
5. Face Size: As noted on drawing.
6. Face Style: Three cone.
7. Mounting: Per drawings.

B. Louver Face Diffuser:
   1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
      b. Carnes.
      c. Krueger.
      d. METALAIRE, Inc.
      e. Nailor Industries Inc.
      f. Price Industries.
      g. Titus.
      h. Tuttle & Bailey.
   2. Devices shall be specifically designed for variable-air-volume flows.
   4. Finish: Baked enamel, white.
   5. Face Size: As noted on drawing.

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:
      b. Krueger.
      c. METALAIRE, Inc.
      d. Nailor Industries Inc.
      e. Price Industries.
      f. Titus.
      g. Tuttle & Bailey.
   3. Finish: Baked enamel, white.
4. Face Blade Arrangement: As noted on drawing.
6. Rear-Blade Arrangement: As noted on drawing.
9. Damper Type: Adjustable opposed blade.

B. Fixed Face Grille

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   b. Anemostat Products; a Mestek company.
   c. Carnes.
   d. Dayus Register & Grille Inc.
   e. Hart & Cooley Inc.
   f. Krueger.
   g. Nailor Industries Inc.
   h. Price Industries.
   i. Titus.
   j. Tuttle & Bailey.
   k. <Insert manufacturer's name>.

3. Finish: Baked enamel, white.
4. Face Arrangement: As Scheduled.
7. Mounting: Countersunk screw.
8. Accessory: Opposed blade damper, where scheduled.

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 23 37 13
SECTION 23 73 13
MODULAR OUTDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Variable-air-volume, single-zone air-handling units.

1.3 PERFORMANCE REQUIREMENTS
A. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
B. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of L/200 where "L" is the unsupported span length within completed casings.
C. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4 SUBMITTALS
A. Product Data: For each air-handling unit indicated.
   1. Unit dimensions and weight.
   2. Cabinet material, metal thickness, finishes, insulation, and accessories.
   3. Fans:
      a. Certified fan-performance curves with system operating conditions indicated.
      b. Certified fan-sound power ratings.
      c. Fan construction and accessories.
      d. Motor ratings, electrical characteristics, and motor accessories.
4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

B. Delegated-Design Submittal: For vibration isolation and seismic restraints indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

C. 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.

D. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control reports.

F. Field quality-control reports.

G. Operation and Maintenance Data: For air-handling units 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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.

D. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
1.6 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.

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. Filters: One set(s) for each air-handling unit.
2. Fan Belts: One set(s) for each air-handling unit fan.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
A. Manufacturers: Subject to compliance with requirements, provide products as scheduled on the drawings, no substitutions.

1. YORK/Johnson Controls, Inc.

2.2 UNIT CASINGS
A. General Fabrication Requirements for Casings:

1. Forming: Walls, roofs, and floors shall be of double wall construction, with both panels fabricated of galvanized steel.
2. Casing Joints: Sheet metal screws or pop rivets.
3. Sealing: Seal all joints with water-resistant sealant. Maximum allowed leakage is 1% at +/-8" w.c.
4. Factory Finish for Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat, or mill finished galvanized.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
6. Structure Rigidity: Walls, roof and access doors shall deflect no more than L/240 when subjected to +/-8"w.c. Floor shall deflect no more than L/240 when subjected to a 300LB 10ad at mid-spam.
B. Casing Insulation and Adhesive:

1. Materials: Foamed-in-place polyisocyanurate or fiberglass.

2. Location and Application: Encased between outside and inside casing.


C. Inspection and Access Panels and Access Doors:

1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.

2. Inspection and Access Panels:
   a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.

3. Access Doors:
   a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
   b. Gasket: Neoprene, applied around entire perimeters of panel frames.
   c. Size: At least 18 inches (450 mm) wide by full height of unit casing up to a maximum height of 60 inches (1500 mm).

4. Locations and Applications:
   a. Fan Section:
   b. Access Section: Doors.
   c. Coil Section: Inspection and access panel.
   d. Damper Section: Doors.
   e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
   f. Mixing Section: Doors.

D. Condensate Drain Pans:

1. Fabricated with slope in at least two planes in accordance with requirements of ASHRAE 62.1-2004. to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and to direct water toward drain connection.
   b. Depth: A minimum of 2 inches (50 mm) deep.

2. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal. Minimum R value to be R-12. In addition, all condensate piping located inside the AHU shall be insulated.

3. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
5. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

E. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

1. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when air-handling unit frame is anchored to building structure.

2.3 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. Fans on variable volume units shall be direct drive open plenum type fabricated without fan scroll, volute housing or drive assemblies, equipped with factory mounted variable frequency drive.

B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.

C. Internal Vibration Isolation and Seismic Control: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm).

1. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.

D. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Enclosure Type: Totally enclosed, fan cooled.
2. NEMA Premium (TM) 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 Division 26 Sections and as noted below.

E. Variable Frequency Controllers:

1. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
2. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range

3. Unit Operating Requirements:
   a. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent.
   b. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
   c. Minimum Efficiency: 96 percent at 60 Hz, full load.
   d. Minimum Displacement Primary-Side Power Factor: 96 percent.
   e. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   f. Starting Torque: 100 percent of rated torque or as indicated.
   g. Speed Regulation: Plus or minus 1 percent.

4. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

5. Internal Adjustability Capabilities:
   a. Minimum Speed: 5 to 25 percent of maximum rpm.
   b. Maximum Speed: 80 to 100 percent of maximum rpm.
   c. Acceleration: 2 to a minimum of 22 seconds.
   d. Deceleration: 2 to a minimum of 22 seconds.
   e. Current Limit: 50 to a minimum of 110 percent of maximum rating.

6. Self-Protection and Reliability Features:
   a. Input transient protection by means of surge suppressors.
   b. Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
   c. Adjustable motor overload relays capable of NEMA ICS 2, Class 10 performance.
   d. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
   e. Instantaneous line-to-line and line-to-ground overcurrent trips.
   f. Loss-of-phase protection.
   g. Reverse-phase protection.
   h. Short-circuit protection.
   i. Motor overtemperature fault.

7. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

8. Power- Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

9. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.


11. Door-mounted LED status lights shall indicate the following conditions:
   a. Power on.
   b. Run.
c. Overvoltage.
d. Line fault.
e. Overcurrent.
f. External fault.


13. Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

   a. Output frequency (Hertz).
   b. Motor speed (rpm).
   c. Motor status (running, stop, fault).
   d. Motor current (amperes).
   e. Motor torque (percent).
   f. Fault or alarming status (code).
   g. Proportional-integral-derivative (PID) feedback signal (percent).
   h. DC-link voltage (volts direct current).
   i. Set-point frequency (Hertz).
   j. Motor output voltage (volts).

14. Control Signal Interface:

   a. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
   b. Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:

      1) 0 to 10-V dc.
      2) 0-20 or 4-20 mA.
      3) Potentiometer using up/down digital inputs.
      4) Fixed frequencies using digital inputs.
      5) RS485.
      6) Keypad display for local hand operation.

   c. Output signal interface with a minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

      1) Output frequency (Hertz).
      2) Output current (load).
      3) DC-link voltage (volts direct current).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set-point frequency (Hertz).

   d. Remote indication interface with a minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

      1) Motor running.
      2) Set-point speed reached.
      3) Fault and warning indication (overtemperature or overcurrent).
      4) High- or low-speed limits reached.
15. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

16. Integral Disconnecting Means: NEMA KS 1, fusible switch with lockable handle.

17. Accessories:
   a. Devices shall be factory installed in controller enclosure unless otherwise indicated.
   c. Standard Displays:
      1) Output frequency (Hertz).
      2) Set-point frequency (Hertz).
      3) Motor current (amperes).
      4) DC-link voltage (volts direct current).
      5) Motor torque (percent).
      6) Motor speed (rpm).
      7) Motor output voltage (volts).

2.4 COIL SECTION

A. General Requirements for Cooling Coil Section:
   1. Comply with ARI 410.
   2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
   3. Coils shall be fabricated of 0.020" wall thickness copper tube mechanically expanded into aluminum fins, with minimum 18 gage galvanized tube sheets.
   4. Coils shall not act as structural component of unit.
   5. Coils shall be operable at 250 psig and 300°F, and shall be factory tested at 325 psig.
   6. Seismic Fabrication Requirements: Fabricate coil section, internal mounting frame and attachment to coils, and other coil section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" when coil-mounting frame and air-handling-unit mounting frame are anchored to building structure.
   7. Provide minimum 24" deep piping vestibule on one side of the unit, full width of the coil section for coil piping. Vestibule shall match unit construction and shall be complete with hinged and latched access door and shall be sized to accommodate all service and control valves.

   2. Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
   3. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
   4. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
5. Control Panel: Unit mounted with disconnecting means and overcurrent protection.
   a. Magnetic contractor.
   b. SCR Controller.
   c. Time-delay relay.
   d. Pilot lights, one per step.
   e. Airflow proving switch.

2.5 AIR FILTRATION SECTION

A. General Requirements for Air Filtration Section:
   1. Comply with NFPA 90A.
   2. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency
      reporting value (MERV) according to ASHRAE 52.2.
   3. Provide filter holding frames arranged for flat or angular orientation, with access doors on
      both sides of unit. Filters shall be removable from one side or lifted out from access
      plenum.

B. Extended-Surface, Disposable Panel Filters:
   1. Factory-fabricated, dry, extended-surface type.
   2. Thickness: 2 inches (50 mm)
   4. Media: Fibrous material formed into deep-V-shaped pleats and held by self-supporting
      wire grid.
   6. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for
      bolting together into built-up filter banks.

C. Filter Gage:
   1. 3-1/2-inch- (90-mm-) diameter, diaphragm-actuated dial in metal case.
   2. Vent valves.
   3. Black figures on white background.
   4. Front recalibration adjustment.
   5. 2 percent of full-scale accuracy.
   6. Range: 0- to 2.0-inch wg (0 to 500 Pa).
   7. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm)
      aluminum tubing, and 2- or 3-way vent valves.

2.6 DAMPERS

A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory
   Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-
   fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.

B. Damper Operators: Comply with requirements in Division 23 Section "Instrumentation and
   Control for HVAC."

D. Combination Filter and Mixing Section:

2.7 ACCESSORIES

A. Duplex, 115-V, ground-fault-interrupter outlet with 15-A overcurrent protection. Include transformer if required. Outlet shall be energized even if the unit main disconnect is open.

B. Filter differential pressure switch with sensor tubing on either side of filter. Set for final filter pressure loss.

2.8 ROOF CURBS

A. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.

1. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
   a. Materials: ASTM C 1071, Type I or II.
   b. Thickness: 1 inch (25 mm)

2. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
   a. Liner Adhesive: Comply with ASTM C 916, Type I.
   b. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
   c. Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service air velocity.
   d. Liner Adhesive: Comply with ASTM C 916, Type I.

B. Curb Height: 14 inches (355 mm).

C. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match RTU, used to anchor unit to the curb, and designed for loads at Project site. Comply with requirements in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment" for wind-load requirements.
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. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for 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: Install air-handling units on vibration isolated roof cub with seismic restraints. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

B. Arrange installation of units to provide access space around air-handling units for service and maintenance.

C. 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.

D. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using ASTM B 88, Type M (ASTM B 88M, Type C) copper tubing. Extend as shown on drawings to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
F. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:
   1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
   2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

E. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks according to manufacturer's written instructions.
   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 zone dampers fully open and close for each zone.
   7. Verify that face-and-bypass dampers provide full face flow.
   8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
   10. Verify that proper thermal-overload protection is installed for electric coils.
   11. Install new, clean filters.
   12. 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.
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.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13
SECTION 23 81 26
SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ductless split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed ductless mounting.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

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

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

F. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

1.5 COORDINATION

A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

B. Coordinate size, location, and connection details with roof curbs, equipment supports, and roof penetrations specified in Division 07 Section "Roof Accessories."

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, products shall be as manufactured by GREE, no exceptions.

2.2 WALL-MOUNTED, EVAPORATOR-FAN COMPONENTS

A. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.

1. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.


B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

C. Fan: Direct drive, centrifugal fan, with integral condensate pump.

D. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.

E. Filters: Permanent, cleanable.
2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

A. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.

B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
   1. Compressor Type: Inverter-driven.
   2. Refrigerant: R-410A.

C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.

D. Fan: Aluminum-propeller type, directly connected to motor.

E. Motor: Permanently lubricated, with integral thermal-overload protection.

F. Low Ambient Kit: Permits operation down to 45 deg F (7 deg C).

G. Mounting Base: Polyethylene.


2.4 ACCESSORIES

A. Control equipment and sequence of operation are specified in other Division 23 Sections.

B. Thermostat: Low voltage with subbase to control compressor and evaporator fan.

C. Automatic-reset timer to prevent rapid cycling of compressor.

D. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
   1. Minimum Insulation Thickness: 1/2 inch (13 mm) thick.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
C. Install ground-mounting, compressor-condenser components on 4-inch- (100-mm-) thick, reinforced concrete base; 4 inches (100 mm) larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete." Coordinate anchor installation with concrete base.

D. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

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

END OF SECTION 23 81 26
SECTION 23 82 39
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:

1. Propeller unit heaters with electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building Automation System.

B. PTFE: Polytetrafluoroethylene plastic.

C. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Details of anchorages and attachments to structure and to supported equipment.

2. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.

3. Location and arrangement of integral controls.


C. Field quality-control test reports.

D. Operation and Maintenance Data: For cabinet unit heaters 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."


PART 2 - PRODUCTS

2.1 PROPELLER UNIT HEATERS

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. Airtherm; a Mestek Company.
2. Berko Electric Heating; a division of Marley Engineered Products.
4. QMark Electric Heating; a division of Marley Engineered Products.

B. Description: An assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.

C. Comply with UL 2021.

D. Comply with UL 823.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and tested propeller unit heater before shipping.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

H. Discharge Louver: Adjustable fin diffuser for horizontal units.

I. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.

2. Wiring Terminations: Stainless-steel or corrosion-resistant material.
J. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

K. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

   1. Motor Type: Permanently lubricated, single speed, totally enclosed.

L. Control Devices:

   1. Wall-mounting fan-speed switch.
   2. Wall-mounting thermostat.
   3. Interlock with BMS.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants."

B. Install propeller unit heaters level and plumb.

C. Suspend propeller unit heaters from structure with all-thread hanger rods. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Install wall-mounting 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. Comply with safety requirements in UL 1995.

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.”

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. 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. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

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END OF SECTION
SECTION 26 00 00
ELECTRICAL SYSTEMS

1.0 GENERAL

1.1 DESCRIPTION

A. The work under this Section shall conform to the requirements of "Division 1, General Requirements," "Conditions of the Contract" and "Supplementary Conditions." Specific attention is called to the "Division 26 General Requirements" located in Section 26001.

B. It is the intent of these Specifications for the Contractor to provide an electrical system complete, fully operational, fully adjusted, and ready for use.

1.3 PARTIAL LIST OF WORK NOT INCLUDED IN DIVISION 26

A. Equipment pads:
B. Installing access doors:
C. Painting (except as otherwise specified herein):
D. Furnishing of motors: Division 23.
E. Furnishing of individual motor controllers that are factory-mounted and integral parts of pieces of equipment: Division 23.
F. Furnishing, installing, and connecting telephone wiring, cables, and equipment:
G. Compaction testing:
H. Division 23 shall furnish and install control wiring and conduit for the following:
   1. Motor control interlock wiring for automatic temperature control of pumps, WCU's, AHU's, and fans including chilled, heating hot water and condenser water system controls, flow switches, pressure differential controls, compression tank alarms, nitrogen pressurization system, water treatment system, etc.
   2. Sewage ejector and sump pump controls and alarms.
   3. Water system controls and alarms including but not limited to: Domestic water pumps, fire pumps, house pumps, surge tanks, etc.
   4. Wiring for central alarm panel (CAP).
   5. Interlocking of pumps, WCU's, AHU's, and fans to building management system relays
   6. Connection of all safety devices, alarms and control wiring for air compressors including controls for air dryers.
   7. Any control wiring for thermostats, direct digital controls, control valves, dampers, ATC cabinets, etc. for automatic temperature control. Control wiring shall be considered both "line 120 & 277V." and "low" voltage wiring.

Any control wiring not listed above shall be furnished and installed under Division 26, including but not limited to conduit, other raceway components, and control wiring between water meters and remotely mounted water meters.

I. Unit Pricing and Budgetary Cost Estimate

The Contractor shall provide unit prices and budgetary cost estimates as indicated in the Architectural Documents, as specified herein, and as indicated on the Drawings.

1.4 DIVISION 23 REQUIREMENTS

It shall be the responsibility of the Electrical Contractor to review the following Division 23
Specification Sections to determine the complete scope of Division 26 work:

Division 21  Fire Protection System
Section 230900  Building Management System

2.0 PRODUCTS

2.1 EQUIPMENT

A. General: All equipment shall be new, of the capacity and type specified herein, and as shown on the Drawings. Equipment shall be of a listed manufacturer and model number and shall be in accordance with the space limitations of the project.

B. Single Source: To maximize ease of maintenance and part replacement, equipment of a similar nature shall be provided by a single manufacturer.

C. Approved Equal: Equipment and materials selected by the Contractor within the context of "equal as approved by the Engineer", "approved equal", "equivalent as determined by the Engineer" and similar terminology shall be submitted to the Engineer for review, approval and inclusion into the Contract Documents prior to the finalization of the contract between the Owner and the Contractor, and prior to the shop drawing submittal phase of the Project. All equipment and materials submitted to the Engineer under the terms of "approved equal" during the shop drawing phase of the Project without prior review and approval shall be returned to the Contractor without review under the status of "No Action".

2.2 MATERIAL

All material required for a complete and proper installation shall be as specified and as selected by the Contractor subject to the approval of the Architect. Material shall be new, listed and approved by UL, and bear the inspection label if subject to such approval.

3.0 EXECUTION

3.1 CONDITIONS

A. Inspection: Prior to proceeding with the work of this Division, 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 Division may be completed in strict accordance with all pertinent codes and regulations, the reviewed shop drawings, and the manufacturers' recommendations.

B. Discrepancies: In the event of discrepancy, immediately notify the Owner's Representative. Do not proceed in areas of discrepancy until all such discrepancies have been resolved. If there is a discrepancy between the Drawings and the Specifications, the Specifications shall typically govern. However, any discrepancy of this type shall be immediately brought to the attention of the Owner's Representative for formal interpretation prior to proceeding with the work.

C. Interpretation of Documents: Any and all contractual requirements may be indicated solely on the Drawings, solely in the Specifications, in both the Specifications and on the
Drawings, in reference standards indicated in the Specifications and/or in the Owner's and Contractor's Contract. If Contract requirements are indicated in both the Specifications and the Drawings, the Contractor shall comply with both requirements unless the requirements are mutually exclusive of each other. If Contract requirements are indicated in both a reference standard and the Specifications, the more stringent requirement shall apply. Any and all contractual requirements shall be interpreted within the overall context of the complete scope of work. All materials, equipment, systems and installation methods shall be suitable for the intended service, coordinated with other trades and be complete, fully operational, adjusted, tested and ready for use by the Owner.

3.2 INSTALLATION OF EQUIPMENT

A. Locations: Install all equipment in the locations shown on the approved shop drawings, except where specifically approved otherwise on the job by the Architect and/or Owner's Representative.

B. Interferences: Avoid interference with structure and with work of other trades, while preserving adequate headroom and clearing all doors and passageways to the approval of the Architect and/or Owner's Representative.

Where busway is installed on a job, Electrical Contractor shall coordinate location early with other trades. Horizontal runs of bus shall be run above all piping and ductwork so as to maximize clear headroom below busway and maintain manufacturer's recommended access clearances to all sides of busway. All section joints shall be accessible.

C. Inspection: Check each piece of equipment in the system for defects. Verify that all parts are properly furnished and installed, function properly, and that all adjustments have been made.

3.3 CONNECTIONS TO EQUIPMENT

A. Mechanical Equipment: The Contractor shall make final electrical connections to all items of mechanical equipment, including all motors and unit heaters for a complete and operational system.

B. Elevator Connections: The Contractor shall make final connections to the elevator control panel(s) and provide the required outlets for the elevator accessories as required by the elevator manufacturer. Padlocking hardware will be provided for all circuit breakers or disconnects in elevator machine room(s). Enclosed fused disconnects or circuit breakers will be provided for all elevators within the elevator machine room "in sight" of elevator controllers. Contractor shall provide a 160° heat detector independent of the fire alarm system hard wired to the 120 volt standby power system with 120V., 20A. rated contact(s). Control wiring shall be provided such that upon activation of detector, a standby powered 120V., 20A. circuit shall be completed which shall shunt trip "off" main line power to elevator controllers. All work for the elevator installation shall be in accordance with applicable requirements of the ANSI Standard Safety Code for Elevators, Dumbwaiters, Escalators, and Moving Walks, A17.1, published by the American Society of Mechanical Engineers.

3.4 CLOSING-IN OF UNINSPECTED WORK

A. General: Do not allow or cause any of the work of this Division to be covered up or enclosed until it has been inspected, tested, and approved by the Architect and/or Owner's Representative and by the authorities having jurisdiction.

B. Uncovering: Should any of the work of this Division be covered up or enclosed before it
has been completely inspected, tested and approved, the Contractor shall provide all services, labor, materials and equipment necessary to uncover such work without additional cost to the Owner. After the work has been completely inspected, tested, and approved, the Contractor shall provide all services, labor, materials and equipment to make all repairs necessary to restore the work to its original and proper condition at no additional cost to the Owner.

3.5 COOPERATION WITH OTHER TRADES

Coordinate and cooperate with other trades in order that all systems in the scope of the Contract may be installed in the best arrangement. Coordinate and cooperate as required with all other trades which share space in common areas and maximize the access to each system and their respective components.

3.6 CLEANING

It is the intent of these Specifications that all work, including the inside of equipment, be left in a clean condition. All construction dirt shall be removed from material and equipment. Level of cleanliness shall be defined as "broom" clean unless noted otherwise. All exterior surfaces of Division 26 equipment shall be wiped down and cleaned of all dust and dirt. All interior surfaces of electrical equipment including but not limited to switchboards, motor controllers, and panelboards shall be wiped down and vacuum cleaned. Surfaces to be painted shall be cleaned and prepared in accordance with architectural division of the contract and as noted in other sections herein.

3.7 COMPLETENESS

It is the intent of these Specifications to provide a complete system. Completeness shall mean not only that all material and equipment have been installed properly, but that all material and equipment have been installed and have been adjusted, and that, in the opinion of the Architect, all material and equipment are operating as designed.

3.8 ADJUSTMENT OF CONTROLS

The Contractor shall provide the personnel and equipment to completely adjust the controls to the satisfaction of the Architect. At the completion of the project, the Architect will arrange a meeting at the job site to allow the Contractor to demonstrate the proper operation of the electrical controls.

3.9 NOISE

It is the intent of these Specifications to provide a system free from objectionable noise. Any equipment that is generating objectionable noise, in the opinion of the Architect, shall be corrected and other noises shall be dampened as directed.

END OF SECTION
SECTION 26 00 01
DIVISION 26 GENERAL REQUIREMENTS

1.0 GENERAL

1.1 DESCRIPTION

A. General
The work required under this Section shall conform to the requirements of "Division 1, General Requirements," Conditions of the "Contract" and "Supplementary Conditions".

B. Work Included
The work included in this Section consists of the general requirements for the work more specifically described in Division 23 and Division 26 where referenced.

C. Definitions
The Contractor shall provide all supervision, labor, material, equipment, machinery, and any and all other items necessary to complete the mechanical and electrical systems. All items of equipment are specified in the singular; however, the Contractor shall provide the number of items of equipment as indicated on the Drawings, and as required for complete systems.

D. Intent
It is the intention of these Specifications and Drawings to call for finished work, tested, and ready for operation. Wherever the word "provide" is used, it shall mean "furnish and install complete and ready to use."

All labor, materials, apparatus, and appliances essential to the complete functioning of the systems described and/or indicated herein, or which may be reasonably implied as essential whether mentioned in the Contract Drawings and Specifications or not, shall be furnished and installed by the Contractor.

In cases of doubt as to the Work intended, or in the event of need for explanation thereof, the Contractor shall request supplementary instructions from the Architect.

E. Codes, Rules, Regulations, Permits and Fees
The Contractor shall give all necessary notices, obtain all permits and pay all government sales taxes, fees, and other costs, including utility connections or extensions, in connection with the Contractor's work; file all necessary plans, prepare all documents and obtain all necessary approvals of all governmental departments having jurisdiction; obtain all required certificates of inspection of the Contractor's work and deliver same to the Architect before request for acceptance and final payment for work.

The Contractor shall comply with the most recently revised versions of all applicable laws, rules, regulations, and ordinances of Federal, State, and Local Authorities. Modifications required by the above said Authorities shall be made without additional charge to the Owner.

All equipment shall comply with all applicable requirements of laws, codes,
ordinances, legislation, etc., of all Federal, State and Local Authorities, whether indicated on the Contract Documents or not.

Where Contract Drawings and Specifications requirements are in excess of Code requirements and are permitted under the Code, the Contract Drawings and Specifications shall govern.

All rules and regulations of the State Fire Insurance Regulatory Body, Underwriters Laboratories, the Local Building Code, Americans with Disabilities Act (ADA), and National Electrical Code (NEC), shall be complied with whether indicated in the Contract Drawings and Specifications or not.

Where alterations to and/or deviations from the Contract Drawings and Specifications are required by the above authorities, report the requirements to the Architect and secure Architect's approval before starting the alterations.

1.2 QUALITY ASSURANCE

A. Surveys and Measurements
The Contractor shall base all measurements, both horizontal and vertical, from established bench marks. All work shall agree with these established lines and levels. Verify all measurements at site and check the correctness of same as related to the work.

Should the Contractor discover any discrepancy between actual measurements and those indicated, which prevents following good practice or the intent of the Drawings and Specifications, the Contractor shall notify the Architect, and shall not proceed with the work until instruction has been received from the Architect.

B. Drawings
Drawings are diagrammatic and indicate the general arrangement of systems and work included in the Contract. Drawings are not to be scaled. The Architectural Drawings and Details shall be examined for exact location of fixtures and equipment. Where they are not definitely located, this information shall be obtained from the Owner's Representative.

The Contractor shall follow Drawings in laying out work and check Drawings of other trades to verify spaces in which work will be installed. Maintain maximum headroom and space conditions at all points. Where headroom or space conditions appear inadequate, the Owner's Representative shall be notified before proceeding with installation.

If directed by the Owner's Representative, the Contractor shall, without extra charge, make reasonable modifications in the layout as needed to prevent conflict with work of other trades or for proper execution of the work, if such directions are made prior to the performance of the affected work.

C. Cooperation with Other Trades
The Subcontractors shall give full cooperation to other trades and shall furnish in writing to the General Contractor any information necessary to permit the work of all trades to be installed satisfactorily and with the least possible interference or delay.

Where Division 23 and 26 work will be installed in close proximity to, or will interfere
with work of other trades, coordination among trades in working out space conditions to make a satisfactory adjustment shall be accomplished.

The Contractor shall prepare composite shop drawings and sections at a suitable scale not less than 1/4" = 1'0", clearly showing how work of all affected trades is to be installed. If work is installed before coordinating with other trades, or so as to cause any interference with work of other trades, then the necessary changes in work shall be made to correct the condition without extra charge.

The Contractor shall obtain and transmit between affected trades, all necessary templates, patterns, setting plans, and shop details for the proper installation of work and for the purpose of coordinating adjacent work.

Where busway is installed on a job, Electrical Contractor shall coordinate location early with other trades. Horizontal runs of bus shall be run above all piping and ductwork so as to maximize clear headroom below busway and maintain manufacturer's recommended access clearances to all sides of busway. All section joints shall be accessible.

D. Protection

The Contractor shall protect all work and material from damage by the Contractors' work or workmen, Subcontractors' work or workmen, and shall be liable for all damage thus caused.

The Contractor shall be responsible for work and equipment until work is final inspected, tested, and accepted; the Contractor shall protect work against theft, injury or damage; and shall carefully store material and equipment received on site which are not immediately installed. The Contractor shall close open ends of work with temporary covers or plugs during storage and construction to prevent entry of obstructing material.

E. Material and Workmanship

Work shall be executed in strict accordance with the best practice of the trades in a thorough, substantial, workmanlike manner by competent workmen.

The Contractor shall furnish the services of a full-time, experienced superintendent, who shall be constantly in charge of the installation of the work, together with all skilled workmen, fitters, metal workers, welders, helpers, and laborers required to unload, transfer, erect, connect, adjust, start, operate, and test each system.

F. Manufacturer's Recommendations

With exceptions as specified and/or indicated on the Drawings or in the Specifications, apply, install, connect, erect, use, clean, and condition manufactured articles, materials, and equipment in accordance with manufacturer's current printed recommendations. Keep copies of such printed recommendations at job site and make them available as required. When product conditions are not covered by the manufacturer's printed recommendations, at the discretion of the owner's representative, it may be necessary for the manufacturer's representative to review the product conditions and provide written supplemental recommendations to address the special situation.

G. Space Limitations
Equipment has been chosen which will fit into the physical spaces provided and indicated, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearance in accordance with the Code requirements and the requirements of the local inspection department.

In the preparation of Drawings, a reasonable effort to accommodate approved equipment manufacturer's space requirements has been made. However, since space requirements and equipment arrangement vary according to each manufacturer, the responsibility for initial access and proper fit rests with the Contractor. The Contractor will be responsible for obtaining approvals from the Engineer and Local Authority where equipment the Contractor is providing on the Project differs in size or space considerations from that shown on Contract Documents.

Physical dimensions and arrangements of equipment to be installed shall be subject to the Architect's review.

H. Coordination Between Divisions 23 and 26
The Division 26 contractor shall cooperate with the general contractor and the Division 23 contractor to provide coordination between the Division 23 and 26 trades. For all equipment requiring electrical service provided under Division 23, it shall be the responsibility of the Division 26 contractor to acquire from the Division 23 contractor the electrical characteristics of the actual equipment to be provided. Should there be a discrepancy between the electrical service characteristics of the equipment to be provided and what is indicated on the documents, the contractor shall obtain written direction from the Owner's representative prior to proceeding. This coordination and transfer of information shall take place prior to the purchasing and installation of the electrical service.

1.3 SHOP DRAWINGS, PRODUCT DATA AND SAMPLES

A. After the Contract is awarded, but prior to proceeding with the Work requiring final reviewed shop drawings, product data and samples, the Contractor shall obtain complete shop drawings, product data and samples from the manufacturers, suppliers, vendors, Subcontractors, and Sub-Subcontractors for all materials, systems and equipment specified herein; and submit data and details of such materials, systems and equipment for review by the Architect and Engineer. Prior to submittal of the shop drawings, product data and samples to the Architect and Engineer, the Contractor shall review and certify that the shop drawings, product data and samples are in compliance with Contract Documents. Further, the Contractor shall check all materials and equipment after their arrival on the job site and verify their compliance with the Contract Documents. A minimum period of two weeks, exclusive of transmittal time, will be required in the Engineer's office each time a shop drawing, product data and/or samples are submitted or resubmitted for review. This time period shall be considered by the Contractor when scheduling the Work.

B. The Architect's approval and Engineer's review of shop drawings, product data, and samples shall not relieve the Contractor of the responsibility for dimensions or errors that may be contained therein, or for deviations from requirements in the Contract Documents. It shall be clearly understood that the Engineer's noting some errors but overlooking others does not grant the Contractor permission to proceed in error. Regardless of any information contained in the shop drawings, product data and samples, the Contract Documents shall govern the Work and are neither waived nor superseded in any way by the review of shop drawings, product data and samples.
C. Before submitting shop drawings, product data and samples the Contractor shall certify that data and details set forth on each shop drawing, product data, or samples for each item of equipment and materials complies with the Contract Documents for this Project. Such certification shall be made by the Owner, a Partner, a Corporate Officer of the Contractor, or by a person duly authorized to sign binding agreements for the Contractor. Unless certified, shop drawings, product data and samples will not be reviewed, and will be returned unchecked to the Contractor. Certifications shall be in the form of rubber stamp impressions which state:

I hereby certify that this shop drawing, product data, and/or sample has been checked prior to submittal and that it complies in all respects with the requirements of the Contract Documents and physical space limitations for the Project.

(Name of the Electrical Subcontractor)

Signed: ________________________

Position: _______________________

Date: ___________________________

D. The Contractor shall submit shop drawings, product data and/or samples equipment and other items listed in Section 26900 and for any other equipment for which such submittals may be required in various Sections of the Specifications.

E. Inadequate or incomplete shop drawings, product data and/or samples will not be reviewed by the Architect or the Engineer and shall be returned to the Contractor for resubmittal.

F. The Contractor shall observe the following rules when submitting shop drawings, product data and samples:

1. Each shop drawing shall indicate in the lower right hand corner, and each product data brochure shall indicate on the front cover the following: title of the sheet or brochure; name and location of the Project; names of the Architect and Engineer, Contractor, Subcontractor, manufacturer, supplier, vendor; the date of submittal; and the date of each correction and revision. So far as is practical, each shop drawing, product data and/or sample shall bear a cross-reference note to the page number or numbers of sheets of the Drawings and/or Specifications showing the Work. Unless the above information is included, the submittal will be returned for resubmittal.

2. Shop drawings shall be done in an easily legible scale and shall contain sufficient plans, elevations, sections and schematics to clearly describe the apparatus. Drawings shall be prepared by an engineer-draftsman skilled in this type of work. All bus duct layouts and similar shop drawings shall be drawn to at least 1/4" = 1'-0" scale. The Contractor shall submit shop drawings as described below. Shop drawings which do not comply with these requirements will be returned for resubmittal.
a. The submittal shall consist of two prints and one sepia of the shop drawing. The Architect and Engineer will each retain one print, and should the shop drawing receive a “RESUBMIT” status the sepia will be returned to the Contractor. Should the submittal receive a status of "FINAL REVIEW" or "REVIEWED, EXCEPTIONS NOTED", the sepia will be returned to the Contractor with the appropriate action indicated. Should the submittal be marked "RESUBMIT", it shall be resubmitted in accordance with the Contract Documents. If marked "FINAL REVIEW", no resubmittal is required, and if marked "REVIEWED, EXCEPTIONS NOTED", documentation in the form of a letter or complete resubmittal of shop drawing shall be forwarded to the Owner and Engineer for record purposes only.

b. If the copy stamped "FINAL REVIEW" is altered for any reason after it has been stamped, the "FINAL REVIEW" shall automatically be voided.

c. All work shall be done in accordance with shop drawings stamped "FINAL REVIEW" or "REVIEWED, EXCEPTIONS NOTED", insofar as these are in agreement with the Contract Documents. Wherever differences occur between the shop drawings and the Contract Documents, the Contract Documents shall govern the Work.

3. Product data to be submitted shall be published by the manufacturers and shall contain complete and detailed engineering and dimensional information. The Contractor shall submit product data as described below. Product data which does not comply with these requirements will be returned for resubmittal.

a. Product data submitted shall contain only information relevant to the particular equipment or materials to be furnished. The Contractor shall not submit catalogs which describe several different items in addition to those items to be used, unless all irrelevant information is clearly marked out, or unless relevant information is clearly marked. Product data from each manufacturer shall be identified and submitted separately.

b. The submittal shall consist of product data from each manufacturer. Product data will be returned marked "FINAL REVIEW", "REVIEWED, EXCEPTIONS NOTED", or "RESUBMIT". If stamped "RESUBMIT", the product data so marked shall be returned and the submittal repeated in accordance with Contract Documents. If marked "REVIEWED, EXCEPTIONS NOTED" the submittal shall be corrected as noted and returned for Owner's and Engineer's permanent record. If marked "FINAL REVIEW" no additional submittal will be required.

c. If the product data stamped "FINAL REVIEW" are altered for any reason after they have been stamped, the "FINAL REVIEW" shall automatically be voided.

d. All work shall be done in accordance with product data stamped "FINAL REVIEW" or "REVIEWED, EXCEPTIONS NOTED" insofar as these are in agreement with the Contract Documents. Wherever differences occur between the product data and Contract Documents, the Contract Documents shall govern the Work.

e. The Contractor shall submit eight (8) copies of each product data brochure. The Architect and Engineer will each retain one copy of the submittal and six (6) copies will be returned to the Contractor.

G. Equipment Deviations
Where the Contractor proposes to use an item of equipment other than that specified or detailed on the drawings, which requires any redesign of the structure, partitions, foundations, piping, wiring or any other part of the mechanical, electrical, structural, or architectural layout, all such redesign, and all new drawings and detailing required therefore, shall be prepared by the Contractor at the Contractor's own expense as approved by the Owner's Representative.

Where such approved deviation requires a different quantity and arrangement of ductwork, piping, wiring, conduit and equipment from that specified or indicated on the Drawings, the Contractor shall furnish and install any such ductwork, piping, structural supports, insulation, controllers, motors, starters, electrical wiring, and conduit, and any other additional equipment required by the system, at no additional cost to the owner.

1.4 WARRANTY

All equipment supplied for this Contract shall be free from defects in material, workmanship, and title, and shall be of the kind and quality described herein. If it appears within one year from date of building final acceptance by the Owner that the equipment does not meet the warranties specified above, the Contractor shall correct any defect, including nonconformance with these Specifications, at the Contractor's option, either by repairing any defective part or parts or by making available at the Contractor's plant a repaired or replacement part.

1.5 CONFERENCE PRIOR TO START OF WORK

A. Immediately upon the award of this Contract, but prior to commencing any Work, the Contractor together with designated major Subcontractors shall confer with the Owner's Representative, the Architect and Engineer concerning the Work under this Contract.

B. Contractors and Subcontractors attending this meeting shall include but not be limited to the following: General; Mechanical; Plumbing; Fire Protection; Automatic Temperature Controls and Building Management; Sheet Metal; Insulation; Electrical; Fire Alarm; and Testing, Balancing and Adjusting. Contractor and Subcontractor representatives shall be familiar with the Drawings, Specifications and shop drawing submittal requirements and be prepared to intelligently discuss the project requirements.

C. The conference shall be as determined by Architect.

2.0 PRODUCTS

2.1 MATERIALS

A. Materials and equipment shall be new and in good condition. The commercially standard items of equipment and the specific names mentioned herein are intended to identify standards of quality and performance necessary for the proper functioning of the Work.

B. Since manufacturing methods vary, reasonable minor variations are expected; however, performance and material requirements specified are the minimum standards acceptable. The Engineer retains the right to judge equality of equipment that deviates from the Contract Drawings and Specifications.
2.2 EQUIPMENT PADS AND ANCHOR BOLTS

A. Concrete pads for various pieces of equipment will be provided under another Division. Pads shall be provided in main switchboards rooms, all areas with floors below grade, penthouse equipment rooms and electrical closets and any other locations as shown on the drawings. This shall include floor mounted equipment, equipment mounted on legs and pipe support stands. Unless otherwise noted, equipment pads shall generally conform to the shape of the piece of equipment it serves with a minimum 3" margin around the equipment and supports. Pads shall be a minimum of 4" high and made of a minimum 28 day, 2500 psi concrete reinforced with 6" x 6" 6/6 gauge welded wire mesh. Tops and sides of pad shall be troweled to smooth finishes, equal to those of the floors, with all external corners bull-nosed to a 3/4" radius. Shop drawings stamped "FINAL REVIEW" or "REVIEWED EXCEPTIONS NOTED" shall be used for dimensional guidance in sizing pads.

B. Unless otherwise noted furnish and install galvanized anchor bolts for all equipment placed on concrete equipment pads or on concrete slabs. Minimum dimension between anchor bolts and edge of slab shall not be less than 3". Bolts shall be of the size, type and number recommended by the manufacturer of the equipment and shall be located by means of suitable templates provided by the equipment manufacturer.

2.3 EQUIPMENT MOUNTING/SUPPORT DEVICES

A. All floor, wall or ceiling mounting/support devices shall be factory fabricated devices as provided by the equipment manufacturer for the intended application unless otherwise indicated on the Drawings.

B. The Engineer retains the right to judge the quality of the design, application, and installation of all field fabricated mounting/support devices using steel angle, steel channels, Uni-Strut, brackets, all-thread rods, etc. Any mounting or support devices that will rust, corrode or in the opinion of the Engineer become unsightly or a maintenance problem will not be acceptable.

C. Support devices not factory finished shall be hot dipped galvanized or properly primed and painted with a minimum of two coats of rust inhibiting paint. Refer to the Architectural Painting Systems for additional requirements.

D. All-thread rods shall be galvanized or cadmium plated.

E. All plywood used as mounting boards in association with Division 26, unless specified otherwise by the Architect, shall be APA C-D plugged interior 5/8" to 3/4". All plywood used shall be painted (front, back and edges) with a minimum of one prime coat and one finish coat prior to equipment installation. Refer to the Architectural Specifications for additional requirements. Color shall be determined by the Architect.

2.4 ACCESS DOORS

Wherever access is required through walls, ceilings or fire-rated enclosures to concealed equipment installed under this Division, the Contractor shall furnish a hinged access door and frame as follows:

A. Drywall construction--Milcor Style DW.
B. Finished acoustical tile ceiling--Milcor Style AT.
C. Finished plaster ceiling--Milcor Style AP.
D. Finished plaster walls or ceramic tile--Milcor Style M.
E. Plaster or masonry walls and ceilings outside offices and in other finished areas exposed to view--Milcor Style K or M.
F. Access doors shall be "B" label fire construction where required.
G. Access doors shall be installed under another Division.
H. No access door shall be installed until location and type have been approved by the Architect.

2.5 ESCUTCHEONS

Furnish and install heavy chrome-plated or nickel-plated steel plates of approved pattern on all conduit passing through walls and ceilings in finished areas. Escutcheons shall be B & C No. 10 or approved equal with concealed hinges. Pattern shall be approved by the Architect.

3.0 EXECUTION

3.1 SCAFFOLDING, RIGGING, HOISTING

The Contractor shall furnish all scaffolding, rigging, hoisting, and services necessary for erection and delivery of any equipment and apparatus furnished to the job site. Remove same from job site when no longer required.

3.2 SLEEVES, CUTTING, AND PATCHING

A. The Contractor shall be responsible for the timely placing of openings and sleeves for all conduit passing through walls, partitions, beams, floors, and roof while the same are under construction. A conduit sleeve shall be one size larger than the size of conduit it serves, except where "Link Seal" casing seals are used in sleeves through walls below grade. Sleeves set in concrete floor construction shall be 18 gauge galvanized steel. Sleeves shall extend two inches above the finished floor. All conduit passing through concrete or masonry walls shall have standard weight galvanized steel sleeves. Sleeves shall be set flush with finished wall. Caulk around conduit penetrating floors and roof with sufficient layers of fire safing insulation and further seal off opening between conduit and sleeve with a fire rated non-hardening mastic. The fire rating shall equal rating of floor sleeve penetrates.

B. Sleeves penetrating walls below grade shall be standard weight black steel pipe with 1/4" thick steel plate secured to the pipe with continuous fillet weld. The plate shall be located in the middle of the wall and shall be four inches wider all around than the sleeve it encircles. The entire assembly shall be hot dipped galvanized after fabrication. Seal off annular opening between conduit and sleeve with "Link Seal" casing seal as manufactured by Thunderline Corporation, Wayne, Michigan. The sleeve shall be sized to accommodate the Thunderline casing seal. Casing seals shall be Series 300 for conduit sizes 3/4" through 4" and Series 400 for pipe conduit 5" and larger.
C. If holes and/or sleeves are not properly installed and cutting and patching becomes necessary, it shall be done at no expense to the Owner. The Contractor shall undertake no cutting or patching without first securing the Architect's written approval.

3.3 EXCAVATION AND BACKFILL

A. The Contractor shall make all necessary excavations, cutting of paving, concrete, etc., and do all backfilling and paving repairs necessary for the proper execution of the Work. Remove all dirt and debris out of and away from the building as directed. Backfill shall be mechanically compacted to a density of 95% of the maximum dry density at optimum moisture content as determined by the Standard Proctor Compaction Test.

B. Backfill shall be compacted and repairs to paving or concrete shall be accomplished to the satisfaction of the Architect and the Local Authorities.

C. See the various Sections of the Division for additional excavation and backfill requirements.

3.4 PAINTING

A. Painting, except as specified or indicated otherwise, shall be done under another Division. This Division shall cooperate with the other Division to determine the size of equipment, sizes and lengths of pipes, etc., to be painted.

B. Equipment furnished under this Division shall be factory-finished. If the factory finish is damaged during shipment, installation, etc., it shall be repainted subject to the Architect's approval.

3.5 DRAYAGE AND HAULING

Include all drayage, hauling, hoisting, and placement in the building of equipment specified herein. The Contractor shall be responsible for the timely introduction of equipment to the Project. If any item of equipment is received prior to the time it is required, the Contractor shall be responsible for its proper storage and protection until such time as it may be required. The Contractor shall pay for all cost of demurrage or storage.

3.6 IDENTIFICATION OF CIRCUITS AND EQUIPMENT

A. Electrical equipment shall be identified by means of nameplates permanently attached to the equipment. Refer to Section 26195 for additional requirements.

B. Cardholders and directory cards shall be provided for circuit identification in panelboards. Cardholder shall be located on inside of panel door. Directory cards shall be typewritten. Circuit descriptions shall include locations and names of items of equipment served.

C. Circuits and pull wires in empty conduit shall have tags attached to wiring at points where runs are interrupted at junction boxes or terminated in panels, boxes, etc. Feeder or branch circuit numbers shall be indicated.

D. Tag symbols shall correspond to the identifications on the record drawings.
3.7 PROHIBITED LABELS AND IDENTIFICATIONS

A. Prohibited Markings
   Unless otherwise prohibited by applicable codes, in all public areas, tenant areas and similar locations within the Project, the inclusion or installation of any item, element of assembly which bears on any exposed surface any name, trademark, or other insignia which is intended to identify the manufacturer, the vendor, or other source(s) from which such object has been obtained, is prohibited. Also prohibited is the inclusion or installation of any article which bears visible evidence that an insignia, name, label, or other device has been removed.

B. Exception
   Required Underwriters Laboratory labels shall not be removed nor shall identifications specifically required under the various technical sections of the Specifications be removed.

3.8 EQUIPMENT NOISE AND VIBRATION

A. It is the intention to specify and for the Contractor to provide equipment and systems that, as defined herein, shall be quiet and free of apparent noise and vibration in operation.

B. It shall be the responsibility of the Contractor to obtain equipment that is quiet in operation as compared to the other available equipment of its size, capacity, and type, and to install equipment so that a minimum amount of noise and/or vibration is transmitted to the building.

C. Any additional precautions deemed necessary to provide a quiet installation shall be done as part of the Work of the Contractor, subject to review by the Engineer, without additional cost to the Owner. After the system is in operation, it shall be the responsibility of the Contractor to make any changes to equipment or Work installed as may be required to provide a system which is quiet in operation as defined herein.

3.9 DATE OF COMPLETION AND TESTING OF ELECTRICAL SYSTEMS

A. The date for the final acceptance tests shall be sufficiently in advance of the Contract completion date to permit the execution of the test prior to the expiration of the Contract. Any adjustments and/or alterations which the final acceptance tests indicate as necessary for the proper functioning of all equipment shall be completed prior to the expiration of the Contract. Re-tests shall not relieve the Contractor of completion date responsibility. See individual Sections for extent of testing required.

B. The contractor shall provide a detailed schedule of completion indicating when each system is to be completed and outlining when tests will be performed.

3.10 OPERATING INSTRUCTION

A. The Contractor shall provide the services of a factory trained specialist to supervise the operation of all equipment specified herein and to instruct the Owner's operators for a five-day, eight hours per day, operating instruction period. The operating instruction period shall be defined as straight time working hours and shall not include nights, weekends, or travel time to and/or from the Project. See individual Sections for
additional instructions by manufacturer's trained specialists.

B. The Owner shall be notified in writing at least five days before each operating instruction period begins. The Contractor shall not commence instruction period until the Owner has issued a written acceptance of the starting time.

3.11 OPERATING AND MAINTENANCE BOOKS

A. The Contractor shall provide operating instruction and maintenance data books for all equipment and materials furnished under this Division.

B. Submit six copies of operating and maintenance data books for review at least four weeks before final review of the Project. Assemble all data in a completely indexed volume or volumes and identify the size, model, and features indicated for each item.

C. Maintenance instruction manuals shall include complete oiling, cleaning, and servicing data compiled in clearly and easily understandable form. Data shall show all model numbers of each piece of equipment, complete lists of replacement parts, motor ratings, and actual loads.

D. Include the following information where applicable:
   1. Identifying name and mark number as indicated on the Drawings and in the Specifications.
   2. Locations (where several similar items are used, provide a list).
   3. Complete nameplate data.
   4. Certified record drawings and "Final Reviewed" or completely corrected shop drawings.
   5. Parts lists.
   6. Performance curves and data.
   7. Wiring Diagrams.

Manufacturers’ recommend operating and maintenance instructions with all nonapplicable information deleted.

3.12 RECORD DRAWINGS

A. The Contractor shall maintain on a daily basis at the project site a complete set of "Record Drawings" reflecting an accurate dimensional record of all buried or concealed work. In addition, the "Record Drawings" shall be marked to show the precise location of concealed work and equipment, and all changes and deviations in the electrical work from that shown on the Contract Documents. This requirement shall not be construed as authorization for the Contractor to make changes in the layout or work without definite instructions from the Architect. The "Record Drawings" shall consist of a set of black line prints of the Contract Drawings for this Division with the Engineer's seal and Engineer's firm name removed or blacked out. Prior to commencing work, the Contractor shall purchase from the Architect or Engineer a set of black line prints to be used for the "Record Drawings".

B. Record dimensions shall clearly and accurately delineate the Work as installed; locations shall be suitably identified by at least two dimensions to permanent structures.

C. The Contractor shall mark all "Record Drawings" on the front lower right hand corner
"RECORD DRAWINGS (3/8 high letters)  
To be used for recording Field  
Deviations and Dimensional Data  
Only".(5/16" high letters)

D. Upon completion of work, the Contractor shall certify the "Record Drawings"  
for correctness by signing the following certification:

CERTIFIED CORRECT (3/8" high letters)  

(Name of Electrical Subcontractor)

By: _________________________

Date: ________________________

E. Prior to final acceptance of the Work of this Division, the Contractor shall submit  
properly certified "Record Drawings" to the Architect for review and shall make  
changes, corrections, or additions as the Architect may require to the "Record  
Drawings".

3.13 FINAL REVIEW

A. At a time designated, the entire system shall be reviewed for compliance with the  
Contract Drawings and Specifications. The Contractor shall be present at this review.

B. The entire system shall be operating properly with all systems balanced and all  
controls adjusted. All prohibited markings shall be removed from all switchboards,  
panelboards, switches, etc., and the equipment shall be clean and in operating  
condition.

C. Certificates and Documents required herein shall be in order and presented to the  
Architect at least two weeks prior to the review.

D. After the review, any changes or corrections noted as necessary for the Work to  
comply with these Specifications and the Drawings shall be accomplished without  
delay in order to secure final acceptance of the Work.

E. The removal of panel covers, junction box covers, etc., for visual observation of the  
wire, busbars, etc., will not be required at the time of the Final Review if prior review is  
accomplished during construction.

END OF SECTION
SECTION 26 05 00
COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

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

1.2 SUMMARY
A. Section Includes:
   1. Electrical equipment coordination and installation.
   2. Sleeves for raceways and cables.
   4. Common electrical installation requirements.
   5. Energy Management System
   6. Thermographic Testing
   7. Ampacity Test Report
B. Related Sections:
   1. Section 27 05 00 – Common Work Results For Communications
   2. Section 28 05 00 – Common Work Results for Electronic Safety and Security

1.3 SUBMITTALS
A. Product Data: None.

1.4 COORDINATION
A. Coordinate arrangement, mounting, and support of electrical equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

1.5 RECORD DOCUMENTS

A. Record Drawings: Maintain a clean, undamaged set of blue or black line white prints of Contract Drawings and Shop Drawings as required in Division 1 of these specifications. As the work progresses mark the set to show the actual installation where the installation varies substantially from the Work as originally shown. Mark whichever drawing is most capable of showing conditions fully and accurately; where Shop Drawings are used, record a cross reference at the corresponding location on the Contract Drawings. Give particular attention to concealed elements that would be difficult to measure and record at a later date.

1. Mark new information that is important to the Owner, but was not shown on Contract Drawings or Shop Drawings. Include all change order items, bulletins, addenda, or field changes.
2. Organize record drawing sheets into manageable sets, bind with durable paper cover sheets, and print suitable titles, dates and other identification on the cover of each set. Submit the record drawings as part of the project closeout package.
3. Conduit routing on interior and exterior of building for main feeders and ductbanks.
4. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
5. Approved substitutions, contract modifications, and actual equipment and materials installed.
6. Include all "Corrected For Record" shop drawings to reflect approvals received.

B. Engage the services of a Land Surveyor or Professional Engineer to record the locations and invert elevations of all underground installations.

C. Mark Specifications to indicate approved substitutions and actual equipment and materials used.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:
   a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.
   b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.
2.2 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.3 ENERGY MANAGEMENT SYSTEM

A. The Contractor shall provide an Energy Management System as purchased by the Contractor from the following Midwestern State Vendor, with supplementary work by the Contractor:

   Andover Controls

B. The Contractor shall provide the following:

1. Savvy 15 with Baseplate
2. Outdoor Sensor Assembly, including Outdoor Temperature Sensor and Outdoor Analog Light Sensor
3. CBL-2020 7ft RJ11CS Phone Cable
4. Button Override Panel
5. CP-1 Panel, including 24 Volt Power Transformers and Interface Relays
6. Phase Loss Module
7. The Contractor shall provide an 18/8 (18 guage – 8 conductor) wire from the Andover Controls unit to each of the Lighting Control Panels. This cable will provide for control of the lighting and signage.

C. Andover Controls will provide the following:

1. Andover equipment shipping.
2. System programming and download.
3. On-site system start-up.
4. On-site quality assurance test.
5. Telephone verification of remote communications.
6. File transfer final program to MWSU.
7. Warranty of all Andover furnished components for one (1) year from the system start date.
8. CTM Module, 40 VA Transformer.
9. CO2 Sensors.

D. The Contractor shall provide a wire (Belden 8761 or equal) from the electric meter to the Andover Control unit to monitor energy consumption.

E. The Contractor shall provide a wire (Belden 8761 or equal) from the unit heater located in the receiving area to the Andover controller in the electric room. This will allow control for enabling and disabling the unit heater. Temperature settings will be controlled by a wall mounted thermostat.

F. The Contractor shall provide two (2) wires (Belden 8761 or equal) from the outside air assembly mounted on one of the Rooftop Heating/Cooling Units to the Andover control unit in the electric room.
G. The Contractor shall provide a wire (Belden 8761 or equal) from each Rooftop Heating/Cooling Unit to each respective Temperature Sensor mounted in the space.

H. The Contractor shall provide a wire (Belden 8761 or equal) that will be installed from the Andover Control unit in the electric room in a “daisy chain” fashion to each Rooftop Heating/Cooling Unit. That is, the wire will leave the electric room and be run to the next unit and so forth, until all of the Rooftop Heating/Cooling Units have been connected.

I. The Contractor shall coordinate with and pay Andover to arrange system start-up and testing. A Andover representative will make one trip to the job site for system start-up and testing. If for any reason the Andover Technician is unable to complete this work, the Contractor will be billed for travel, expenses, and hourly charges associated with a return visit to the job site for this purpose.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2” above finished floor level.
G. Seal space outside of sleeves with grout for penetrations of concrete and masonry
   1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed
      surfaces smooth; protect grout while curing.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve
   and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
   Comply with requirements in Division 07 Section "Joint Sealants".

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings,
   and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable
   penetration sleeves with firestop materials. Comply with requirements in Division 07 Section
   "Penetration Firestopping."

J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible
   boot-type flashing units applied in coordination with roofing work.

K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using stee pipe sleeves and
   mechanical sleeve seals.

3.3 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical
   installations to restore original fire-resistance rating of assembly. Firestopping materials and
   installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 26 05 00
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. This Section includes the following:
      1. Building wires and cables rated 600 V and less.
      2. Connectors, splices, and terminations rated 600 V and less.
   B. Related Sections include the following:
      1. Section 26 05 00 - Common Work Results For Electrical

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

1.4 QUALITY ASSURANCE
   A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
   B. Comply with NFPA 70.

1.5 COORDINATION
   A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES
   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. American Insulated Wire Corp.
2. General Cable Corporation.

B. Copper Conductors: Comply with NEMA WC 70.
C. Conductor Insulation: Comply with NEMA WC 70 for Types THHN-THWN and SO.
D. Multiconductor Cable: Comply with NEMA WC 70 for Type SO with ground wire.

2.2 CONNECTORS AND SPLICES

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:
   2. O-Z/Gedney
   3. 3M; Electrical Products Division.
   4. Tyco Electronics Corp.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

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.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-THWN, single conductors in raceway.
B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
D. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway
F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.

H. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.

I. Branch Circuits in Cable Tray: Type SO.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. Class 1 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. 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.

C. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips, which will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification 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 and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6" of slack.

3.5 CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

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

END OF SECTION 26 05 19
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
   A. Drawings 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 methods and materials for grounding systems and equipment, plus the
      following special applications:
      1. Common ground bonding with lightning protection system.
      2. Raised Floor

1.3 SUBMITTALS
   A. Product Data: For each type of product indicated.
   B. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding
      features specified in Part 3 "Field Quality Control" Article, including the following:
      1. Test wells.
      2. Ground rods.
      3. Ground rings.
      4. Grounding arrangements and connections for separately derived systems.
      5. Grounding for sensitive electronic equipment.
   C. Field quality-control test reports.
   D. Operation and Maintenance Data: For grounding to include the following in emergency,
      operation, and maintenance manuals:
      1. Instructions for periodic testing and inspection of grounding features at test wells
         NFPA 70B.
         a. Tests shall be to determine if ground resistance or impedance values remain within
            specified maximums, and instructions shall recommend corrective action if they do
            not.
         b. Include recommended testing intervals.
1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:
   4. Bonding Cable: No. 4 or No. 6 AWG, stranded conductor.
   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" wide and 1/16" thick.
   7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8" wide and 1/16" thick.

C. Grounding Bus: Rectangular bars with insulators as indicated in detail on plans.

2.2 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
   1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.3 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel, 3/4" diameter by 10'-0" in length.
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. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
   1. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

C. Conductor Terminations and Connections:
   1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
   2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
   3. Connections to Ground Rods at Test Wells: Bolted connectors.

3.2 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” 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” above to 6” 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 as recommended by manufacturer of splicing and termination kits.

D. Pad-Mounted Transformers and Switches: Install a minimum of 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” from the foundation. Coordinate exact requirements with local Power Company.

E. Raised Floor: Bond from ground bar in space to raised floor pedestal or stringer in one location.

3.3 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. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

E. Metal Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.4 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. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

C. Ground Rods: Drive rods until tops are 2” 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.

D. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12” deep, with cover.

1. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

E. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

F. Grounding and Bonding for Piping:
1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building’s main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

G. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

H. 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'-0” apart.

I. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each indicated item, extending around the perimeter of building.
1. Install tinned-copper conductor not less than No. 4/0 AWG for ground ring and for taps to building steel.
2. Bury ground ring not less than 24” from building foundation.

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal and at ground test wells. Make tests at ground rods before any conductors are connected.
   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.
3. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order,
and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26
PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following:
   1. Hangers and supports for electrical equipment and systems.
   2. Construction requirements for concrete bases.

1.3 DEFINITIONS
A. EMT: Electrical metallic tubing.
B. IMC: Intermediate metal conduit.
C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS
A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS
A. Product Data: For the following:
   1. Steel slotted support systems.
1.6 QUALITY ASSURANCE

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

B. Comply with NFPA 70.

1.7 COORDINATION

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

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

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

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. GS Metals Corp.
e. Thomas & Betts Corporation.
f. Unistrut; Tyco International, Ltd.
g. Wesanco, Inc.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.

3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. 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) Hilti Inc.
      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      5) MKT Fastening, LLC.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.
PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4” in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
   1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.

C. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten 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” thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4” thick.
   6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
   7. To Light Steel: Sheet metal screws.
   8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.

D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Refer to Structural Plans and Specifications for large equipment pads and supports.

B. Construct concrete bases of dimensions indicated but not less than 4” larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

C. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."

D. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29
SECTION 26 05 33
RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

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

1.2 SUMMARY
   A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
   B. Related Sections include the following:
      1. Section 26 05 00 - Common Work Results For Electrical

1.3 DEFINITIONS
   A. EMT: Electrical metallic tubing.
   B. ENT: Electrical nonmetallic tubing.
   C. EPDM: Ethylene propylene diene monomer (M-class) rubber.
   D. FMC: Flexible metal conduit.
   E. IMC: Intermediate metal conduit.
   F. LFMC: Liquidtight flexible metal conduit.
   G. LFNC: Liquidtight flexible nonmetallic conduit.
   H. NBR: Acrylonitrile-butadiene rubber.
   I. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS
   A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover
      enclosures, and cabinets.
   B. Shop Drawings: For the following raceway components. Include plans, elevations, sections,
      details, and attachments to other work.
      1. Custom enclosures and cabinets.
2. For handholes and boxes for underground wiring, including the following:
   a. Duct entry provisions, including locations and duct sizes.
   b. Frame and cover design.
   c. Grounding details.
   d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
   e. Joint details.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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

1. Allied Tube & Conduit; a Tyco International Ltd. Co.
2. O-Z Gedney; a unit of General Signal.
3. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.
D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
   1. Comply with NEMA RN 1.
   2. Coating Thickness: 0.040 inch, minimum.

E. EMT: ANSI C80.3.

F. FMC: Zinc-coated steel.

G. LFMC: Flexible steel conduit with PVC jacket.

H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
   2. Fittings for EMT: Steel, set-screw or compression type.
   3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.

I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.2 NONMETALLIC CONDUIT AND TUBING

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. CANTEX Inc.
   2. RACO; a Hubbell Company.
   3. Thomas & Betts Corporation.

B. ENT: NEMA TC 13.

C. RNC: NEMA TC 2, unless otherwise indicated.

D. LFNC: UL 1660.

E. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.

F. Fittings for LFNC: UL 514B.

2.3 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

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

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Arncor Corporation.
2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.

C. Description: Comply with UL 2024; flexible type, approved for plenum or riser installation based on the installation.

2.4 METAL WIREWAYS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

E. Finish: Manufacturer's standard enamel finish.

2.5 NONMETALLIC WIREWAYS

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. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

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

1. Hoffman.
2. Lamson & Sessions; Carlon Electrical Products.

C. Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.

D. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.6 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finishes in color selected by Architect.
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. Thomas & Betts Corporation
   b. Walker Systems, Inc
   c. Wiremold Company (The)

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.

   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. Hubbell Incorporated; Wiring Device-Kellems Division.
      b. Panduit Corp.
      c. Walker Systems, Inc.
      d. Wiremold Company (The)

2.7 BOXES, ENCLOSURES, AND CABINETS

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

   1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
   2. EGS/Appleton Electric.
   7. RACO; a Hubbell Company.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Metal Floor Boxes: refer to plans.

F. Nonmetallic Floor Boxes: refer to plans.

G. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

H. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.

I. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer’s standard enamel.

J. 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.

2.8 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Comply with SCTE 77.

2. Configuration: Units shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, “ELECTRIC”
6. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
7. Handholes shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.

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. Quazite

2.9 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. 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.
2. 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: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit.
3. Underground Conduit: RNC, Type EPC-80-PVC, direct buried.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFNC.
5. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
6. Application of Handholes and Boxes for Underground Wiring:
   
a. Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
   
   b. Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units, SCTE 77, Tier 8 structural load rating.
   
   c. Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

B. Comply with the following indoor applications, 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: Rigid steel conduit. Includes raceways in the following locations:
   
a. Loading dock.
   
b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   
c. 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: IMC.
7. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway.
8. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway.
9. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: Plenum-type, optical fiber/communications cable raceway.
10. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, 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.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Do not install aluminum conduits in contact with concrete.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:
   1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
   2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.

I. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
   1. 3/4-Inch Trade Size and Smaller: Install raceways in maximum lengths of 50 feet.
   2. 1-Inch Trade Size and Larger: Install raceways in maximum lengths of 75 feet.
   3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

N. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, 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 or LFNC in damp or wet locations not subject to severe physical damage.

O. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

P. Set metal floor boxes level and flush with finished floor surface.

Q. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
2. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
3. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
4. Warning Planks: Bury warning planks approximately 12” above direct-buried conduits on 24” centers. Align planks along the width and along the centerline of conduit.

B. Concrete-Encased Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit.
2. Install conduit in configuration with conduit supports as indicated in the section as shown on the plans.
3. Backfill with concrete per the detail on the plans.
4. Warning Planks: Bury warning planks approximately 12” above direct-buried conduits on 24” centers. Align planks along the width and along the centerline of conduit.
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. Refer to plans for detail.

B. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.

C. 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 the enclosure.

D. 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 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33
PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings 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 steel cable trays and accessories.

1.3 SUBMITTALS
A. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.

B. Shop Drawings: For each type of cable tray.
   1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
   2. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
      a. Design Calculations: Calculate requirements for selecting seismic restraints.
      b. Detail fabrication, including anchorages and attachments to structure and to supported cable trays.

C. Field quality-control reports.

D. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE
A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.
1.5 DELIVERY, STORAGE, AND HANDLING

A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper B-Line, Inc.
2. MONO-SYSTEMS, Inc.

2.2 WIRE BASKET SECTIONS AND COMPONENTS

A. Provide wire basket of types and sizes indicated; with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additions construction features.

B. Wire basket shall be made of high strength steel wires and formed into a standard 2 inch by 4 inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.

C. General: Provide wire basket of types and sizes indicated; with connector assemblies, tool less clips, connector plates, splice plates and splice bars. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.

2.3 MATERIALS AND FINISHES

A. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.

1. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.

B. Sizes and Configurations: Refer to the Drawings for specific requirements for types, materials, sizes, and configurations.

1. Center-hanger supports may not be used.

2.4 WIRE BASKET SUPPORT SYSTEM

A. All straight section longitudinal wires shall be straight (with no bends).
B. Wire basket shall be made of high strength steel wires and formed into a standard 2 inch by 4 inch wire mesh pattern with intersecting wires welded together. All wire ends along wire basket sides (flanges) shall be rounded during manufacturing for safety of cables and installers.

C. Wire basket sizes shall conform to the following nominal criteria:
   1. Straight sections shall be furnished in standard 12 inch lengths.
   2. Wire basket transition sections shall be flat sections 12 inches wide.
   3. Wire basket shall have a 6 inch usable loading depth by 12 inches wide, unless indicated otherwise on the plans.

D. All fittings shall be field formed as needed.

E. All splicing assemblies shall be the bolted type using serrated flange locknuts or using a tool less spring steel fastener hold-down clip at support location.

F. Under Floor: Wire Basket Supports shall be floor stands that are completely independent of the floor structure requiring no tools for assembly. These can be vertically adjustable stands or one piece static stands. Vertically adjustable floor stands shall also have the ability to be stacked on top of each other to allow for multiple tiers of wire basket while still remaining independent of the floor structure. The under floor system is based on the B-Line F.A.S.T. system.

G. Above Ceiling: Provide supports for wall mounted or overhead as dedicated by installation area.

H. Tool less spring steel fastener hold down clips shall be used to secure the wire basket to the support stand and splice wire basket sections together at this support location.

I. Special accessories shall be furnished as required to protect, support multiple runs of wire basket tray and install a wire basket support system.

2.5 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.

B. Barrier Strips: Same materials and finishes as cable tray.

C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

D. Ground Clamp: Provide a stand-off clamp for ground conductor where indicated on plans.

2.6 WARNING SIGNS

A. Lettering: 1-1/2-inch-high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."

B. Materials and fastening are specified in Division 26 Section "Identification for Electrical Systems."
2.7 SOURCE QUALITY CONTROL

A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 CABLE TRAY INSTALLATION

A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.

B. Remove burrs and sharp edges from cable trays.

C. Fasten cable tray supports to building structure and install seismic restraints.
   1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
   2. Place supports so that spans do not exceed maximum spans on schedules.
   3. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
   4. Support bus assembly to prevent twisting from eccentric loading.
   5. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
   6. Locate and install supports according to NEMA VE 1.

D. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.

E. Make changes in direction and elevation using standard fittings.

F. Make cable tray connections using standard fittings.

G. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

H. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.

I. Workspace: Install cable trays with enough space to permit access for installing cables.

J. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.

K. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.
3.2 CABLE INSTALLATION

A. Install cables only when cable tray installation has been completed and inspected.

B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.

C. On vertical runs, fasten cables to tray every 18 inches. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

D. In existing construction, remove inactive or dead cables from cable tray.

E. Install covers after installation of cable is completed.

3.3 CONNECTIONS

A. Ground cable trays according to manufacturer's written instructions.

B. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.

3.4 FIELD QUALITY CONTROL

A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:

1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.

2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.

3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.

4. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.

5. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.

6. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.

7. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.

B. Report results in writing.

3.5 PROTECTION

A. Protect installed cable trays.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
3. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION 26 05 36
SECTION 26 05 48
VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:
   1. Isolation pads.
   2. Spring isolators.
   3. Restrained spring isolators.
   4. Channel support systems.
   5. Restraint cables.
   6. Hanger rod stiffeners.
   7. Anchorage bushings and washers.

B. Related Sections include the following:
   1. Section 26 05 29 - Hangers and Supports for Electrical Systems

1.3 DEFINITIONS


C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:
   1. Site Class as Defined in the IBC: D.
   2. Assigned Seismic Use Group or Building Category as Defined in the IBC: II.

      a. Component Importance Factor: 1.0.
      b. Component Response Modification Factor: 1.5.
      c. Component Amplification Factor: 1.0.

   3. Design Spectral Response Acceleration at Short Periods (0.2 Second): 0.278.
4. Design Spectral Response Acceleration at 1.0-Second Period: 0.096.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
   a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
   b. Annotate to indicate application of each product submitted and compliance with requirements.


B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
   a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:
   a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
   b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
   c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.

D. Welding certificates.
E. Qualification Data: For professional engineer and testing agency.

F. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

E. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
4. Isolation Technology, Inc.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch-thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti Inc.
5. Loos & Co.; Seismic Earthquake Division.
7. TOLCO Incorporated; a brand of NIBCO INC.
8. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

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

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

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

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
   1. Powder coating on springs and housings.
   2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
   3. Baked enamel or powder coat for metal components on isolators for interior use.
   4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.
3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:
   1. Install restrained isolators on electrical equipment.
   2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch.
   3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:
   1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
   2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
   3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
   4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
   5. Set anchors to manufacturer's recommended torque, using a torque wrench.
   6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless post-connection testing has been approved), and with at least seven days’ advance notice.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

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

D. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

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

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 48
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. This Section includes the following:
      1. Identification for raceway and metal-clad cable.
      2. Identification for conductors and communication and control cable.
      4. Warning labels and signs.
      5. Instruction signs.
      7. Miscellaneous identification products.

1.3 SUBMITTALS
   A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE
   A. Comply with NFPA 70.

1.5 COORDINATION
   A. Coordinate identification names, abbreviations, colors, and other features with requirements in
      the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation
      Use consistent designations throughout Project.
   B. Coordinate installation of identifying devices with completion of covering and painting of
      surfaces where devices are to be applied.
   C. Coordinate installation of identifying devices with location of access panels and doors.
   D. Install identifying devices before installing acoustical ceilings and similar concealment.
PART 2 - PRODUCTS

2.1 RACEWAY AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

B. Color for Printed Legend:
   1. Power Circuits: Black letters on an orange field.
   2. Legend: Indicate system or service and voltage, if applicable.

C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

F. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch-thick aluminum sheet, with stamped, embossed, or scribed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking nylon tie fastener.

E. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.
   1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.

1. Not less than 6 inches wide by 4 mils thick.
2. Compounded for permanent direct-burial service.
3. Embedded continuous metallic strip or core.
4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS


B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 7 by 10 inches.

D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch grommets in corners for mounting. Nominal size, 10 by 14 inches.

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR XX INCHES." XX refer to the minimum clearance described in NEC Table 110-26(A)(1).

2.5 INSTRUCTION SIGNS

A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. in. and 1/8 inch thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.
3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS


B. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch.
2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
   2. Tensile Strength: 50 lb, minimum.
   3. Temperature Range: Minus 40 to plus 185 deg F.

B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
   1. Exterior Concrete, Stucco, and Masonry (Other Than Concrete Unit Masonry):
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior concrete and masonry primer.
         2) Finish Coats: Exterior semigloss acrylic enamel.
   2. Exterior Concrete Unit Masonry:
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
         1) Block Filler: Concrete unit masonry block filler.
         2) Finish Coats: Exterior semigloss acrylic enamel.
   3. Exterior Ferrous Metal:
      a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior ferrous-metal primer.
         2) Finish Coats: Exterior semigloss alkyd enamel.
   4. Exterior Zinc-Coated Metal (except Raceways):
      a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Exterior zinc-coated metal primer.
         2) Finish Coats: Exterior semigloss alkyd enamel.
   5. Interior Concrete and Masonry (Other Than Concrete Unit Masonry):
      a. Semigloss Alkyd-Enamel Finish: Two finish coat(s) over a primer.
         1) Primer: Interior concrete and masonry primer.
         2) Finish Coats: Interior semigloss alkyd enamel.
   6. Interior Concrete Unit Masonry:
      a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a block filler.
         1) Block Filler: Concrete unit masonry block filler.
         2) Finish Coats: Interior semigloss acrylic enamel.
7. Interior Gypsum Board:
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior gypsum board primer.
      2) Finish Coats: Interior semigloss acrylic enamel.

8. Interior Ferrous Metal:
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior ferrous-metal primer.
      2) Finish Coats: Interior semigloss acrylic enamel.

9. Interior Zinc-Coated Metal (except Raceways):
   a. Semigloss Acrylic-Enamel Finish: Two finish coat(s) over a primer.
      1) Primer: Interior zinc-coated metal primer.
      2) Finish Coats: Interior semigloss acrylic enamel.

C. 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 APPLICATION

A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A: Identify with orange self-adhesive vinyl label.

B. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands:
   1. Fire Alarm System: Red.
   4. Mechanical and Electrical Supervisory System: Green and blue.
   5. Telecommunication System: Green and yellow.
   6. Control Wiring: Green and red.

C. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use color-coding conductor tape. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

D. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use color-coding conductor tape. Identify each ungrounded conductor according to source and circuit number.

E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

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.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

H. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply self-adhesive warning labels. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. 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.
2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

I. Instruction Signs:

1. Operating Instructions: 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.
2. Emergency Operating Instructions: 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.

J. 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 systems unless equipment is provided with its own identification.

1. Labeling Instructions:
   a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on 1-1/2-inch-high label; where 2 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.

2. Equipment to Be Labeled:
a. Panelboards, electrical cabinets, and enclosures.
b. Access doors and panels for concealed electrical items.
c. Electrical switchgear and switchboards.
d. Transformers.
e. Electrical substations.
f. Emergency system boxes and enclosures.
g. Motor-control centers.
h. Disconnect switches.
i. Enclosed circuit breakers.
j. Motor starters.
k. Push-button stations.
l. Power transfer equipment.
m. Contactors.
n. Remote-controlled switches, dimmer modules, and control devices.
o. Battery inverter units.
p. Battery racks.
q. Power-generating units.
r. Voice and data cable terminal equipment.
s. Master clock and program equipment.
t. Intercommunication and call system master and staff stations.
u. Television/audio components, racks, and controls.
v. Fire-alarm control panel and annunciators.
w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
x. Monitoring and control equipment.
y. Uninterruptible power supply (UPS) equipment.
z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

aa. Power Distribution Units (PDU)

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach nonadhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

F. System Identification Color Banding for Raceways and Cables: Each color 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.

G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.
1. Color shall be factory applied.
2. Colors for 208/120-V Circuits:
   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.
3. Colors for 480/277-V Circuits:
   b. Phase B: Orange.
   c. Phase C: Yellow.

H. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

I. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches overall.

J. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION 26 05 53
SECTION 26 05 73
OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. The contractor shall provide an engineering analysis and coordination study for the entire electrical system. The basic analysis shall include a short-circuit analysis with protective device evaluation, a protective device coordination study and an Arc Flash study.

B. The project shall begin at the point of utility service for the facility and continue down through the system, to all downstream distribution and branch panelboards, motor control centers and significant motor locations.

C. The project shall include any generators and any associated emergency power distribution equipment, including automatic transfer switches and generator ground fault protection.

D. The project will be built in multiple stages. The study shall be performed based on full build-out (i.e. four (4) electrical services, four (4) generators, two (2) UPS systems each with three (3) modules, etc.) and for the equipment being purchased and installed under this contract. The results shall be compared and plan implemented to result in the correct coordination for both stages of build.

1.3 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers’ technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop drawings for equipment effected by the coordination study will not be reviewed until the coordination study has been submitted and approved.

C. Qualification data for firms and persons specified in the “Quality Assurance” Article to demonstrate their capabilities and experience. Include list of completed projects with project names, addresses, names of Engineer and Owner, and other information specified.

D. A one-line diagram of the system shall be included.

E. The final report shall be bound in a three-ring binder.
F. The final report shall contain individual, tabbed sections for each section. Each tabbed section shall contain the information as outlined in Part 2 of this document. Tab 1 shall list the manufacturer’s name, address, general business phone number, after-hours service phone number, spare parts phone number, distributor’s name, address, general business phone number, after hours service phone number and spare parts phone number. Tab 2 shall contain Section 2.2’s short-circuit analysis with protective device evaluation. Tab 3 shall contain Section 2.3’s protective device coordination study. Tab 4 contains Section 2.4’s information and so on.

G. Electronic SKM files with all libraries, at project completion.

1.4 QUALITY ASSURANCE

A. Preparer Qualifications: Firm experienced in the analysis, evaluation, and coordination of electrical distribution systems and similar to the system for this project. Firm must have at a minimum a 4 year record of successful in-service performance.

B. The study shall be prepared in accordance with the latest edition of NETA Std. ATS, NFPA 70B, the “National Electrical Code”, ANSI C2” National Electrical Safety Code”, and ANSI/IEEE Guidelines, as well as manufacturer’s recommendations.

C. Short-Circuit Analysis and Coordination Study shall be performed by a registered Professional Engineer. Study shall be signed and sealed by the Engineer. The Engineer shall have a minimum of eight years of experience in the analysis, evaluation, and coordination of electrical distribution systems.

D. The firm conducting the study shall have one million worth of Professional Liability Insurance in addition to standard general insurance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The study shall be performed by the manufacturer of switchboards, switchgear, panelboards, etc. provider:
   1. Square D
   2. Eaton

2.2 SOFTWARE

A. All studies shall be performed by means of SKM software.

2.3 SHORT-CIRCUIT ANALYSIS WITH PROTECTIVE DEVICE EVALUATION

A. Systematically calculate fault currents based on the available fault current at the facility service entrance. Study preparer shall obtain the available fault current from the local utility.
B. Short-circuit calculations shall be prepared by means of software. Motor contribution shall be incorporated in determining fault levels. Results of short-circuit calculations shall be presented in tabular form and shall include momentary and interrupting fault values for three-phase and phase-to-ground faults.

C. Short-circuit calculations shall be done for every operating scenario possible including, but not limited to, on normal power, on generator power, single ended normal power, generator tied to utility (if applicable) and other possible configurations. Provide short-circuit ratings for worst case scenario used. Issue prior to submittals.

D. Analyze the short-circuit currents by preparing a tabulation comparing the fault levels to the device interrupting ratings. Indicate areas in which integrated/series ratings are utilized. The following information shall be included in the tabulation:

1. Bus identification number.
2. Location identification.
3. Voltage
4. Manufacturer and type of equipment.
5. Device rating.

E. Provide short-circuit ratings for worst case scenario used. Issue prior to submittals.

2.4 PROTECTIVE DEVICE COORDINATION STUDY

A. Prepare coordination time-current characteristic curves to determine the required settings/sizes of the protective devices to maximize selectivity. The utility upstream protective device feeding the facility shall be maintained as the upper limit for coordination. These settings shall be obtained by the preparer, along with any other protective device setting requirements. The coordination curves shall be prepared on log-log paper and illustrate adequate clearing times between series devices. The curves shall be created through the use of the study software package, but must reflect actual protective devices to be installed. Adequate time-current curves shall be generated to depict coordination. In addition, protective device characteristics shall be suitably determined to reflect calculated short-circuit levels at the location. Limit the number of devices to six (6) per curve. If curve requires more than six (6) devices, split into two (2) curves.

B. A narrative analysis shall accompany each coordination curve sheet and describe the coordination and protection in explicit detail. All curve sheets shall be multi-color for improved clarity. Areas lacking complete coordination shall be highlighted and reasons provided for allowing condition to remain or provide solution to resolve situation. System coordination, recommended ratings, and setting of protective devices shall be accomplished by a registered professional electrical engineer with a minimum of eight years of current experience in the coordination of electrical power systems.

C. The following information shall be provided on all curve sheets.

2. Voltage at which curves are plotted.
4. ANSI frequent fault damage curve.
5. Cable insulation damage curves.
6. Transformer inrush point.
7. Single-line for the portion of the system.
8. Motor starting profiles (where applicable).

2.5 ARC FLASH ANALYSIS

A. An arc flash analysis will be performed in conjunction with a short circuit study. The results from the short circuit study will be used to determine arc energy levels at each defined location in the facility for a specified working distance. Based on the arc energy at each defined point, the proper PPE will be determined and if the arc energy level exceeds available PPE ratings, the locations will be noted. Analysis will be provided to determine if any changes can be made in protection system to reduce arc energy levels.

B. Labels: Provide labels for each evaluated location that lists the hazard levels along with the required PPE while working in that area. Provide labels based on the worst case of all study scenarios and 50% of the available fault current on normal power. Labels shall be thermoset nylon, sunlight resistant, multi-color labels. Provide Orange for Category 5 or less and Red for Dangerous.

2.6 SINGLE-LINE DIAGRAM

A. The final report shall include a multi-color single-line diagram of the electrical distribution system within the scope of the project. The single-line shall include:

1. Transformer rating, voltage ratio, impedance, and winding connection.
2. Feeder cable phase, neutral and ground sizes, length of cable, conductor material, and conduit size and type.
3. Switchgear, switchboards, panelboards, MCC’s, fuses, circuit breakers, ATS’s and switches continuous current ratings.
4. Protective relays with appropriate device numbers and CT’s and PT’s with associated ratios.
5. Detailed legend indicating device type identification and other significant details.

PART 3 - EXECUTION

3.1 SUMMARY

A. The results of the system studies shall be summarized in a final report.

B. Where required, copies of the final report shall be submitted to the power company for their review and approval. Approved copies or the report shall be submitted to the Design Engineer.

3.2 FIELD SETTINGS

A. The contractor shall engage the manufacturer’s service group or alternately a qualified independent testing firm to perform field adjustments of the protective devices as required for placing the equipment in final operating condition. The settings shall be in accordance with the approved short circuit study and protective device evaluation/coordination study.
B. Necessary field settings of devices and adjustments and minor modifications to equipment to accomplish conformance with the approved short-circuit and protective device coordination study, shall be carried out by manufacturer's service group.

END OF SECTION 26 05 73
SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements that apply specifically to the commissioning process for electrical systems.

B. The electrical (Divisions 26, 27, 28) contractor's responsibilities are defined in Section 019113 of these specifications. These responsibilities apply to all specialty sub-contractors and major equipment suppliers within Divisions 26, 27 and 28. Each contractor and supplier shall review Section 019113, and their bids shall include for the carrying out of the work described, as it applies to each Section within the Division 26 specifications, individually and collectively.

1.2 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.

1.3 SUBMITTALS

A. Draft Prefunctional Checklists. Starting 4 weeks before substantial completion, submit weekly progress copies of the prefunctional checklists to the Owner.

B. Final Prefunctional Checklists. Complete and submit a copy of the final prefunctional checklists a minimum of 3 days before the scheduled functional test date.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. Provide test equipment as necessary for start-up and testing of electrical equipment as described in Section 019113. Test equipment shall be of sufficient quality and accuracy to test and/or measure system performance.

B. Load Banks: Load banks, including temporary wiring, shall be provided by the electrical contractor to test and commission the PDU's as described in Section 019113. These load banks shall simultaneously provide the load to test and
commission the mechanical systems. Coordinate with the mechanical contractor.

PART 3 - EXECUTION

3.1 SCHEDULING

A. Functional testing shall begin after Prefunctional Checklists are completed, submitted to the Owner, and approved.

3.2 PARTICIPATION IN COMMISSIONING

1. Designate Contractor team members to participate in the Prefunctional Checklists and the Functional Tests as specified in Section 019113.

3.3 ADDITIONAL COMMISSIONING

A. Additional commissioning activities may be required after system adjustments, replacements, and similar activities are completed. The Contractor, suppliers, and Commissioning Authority shall include a reasonable reserve to complete this work as part of their standard contractual obligations.

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. This Section includes the following lighting control devices:
   1. Time switches.
   2. Outdoor photoelectric switches.
   3. Indoor occupancy sensors.
   4. Lighting contactors.
B. Related Sections include the following:
   1. Division 26 Section “Wiring Devices” for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 DEFINITIONS
A. LED: Light-emitting diode.
B. PIR: Passive infrared.

1.4 SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: Show installation details for occupancy and light-level sensors.
   1. Interconnection diagrams showing field-installed wiring.
C. Field quality-control test reports.
D. Operation and Maintenance Data: For each type of product 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.

1.6 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 TIME SWITCHES

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. Intermatic, Inc.
3. Square D; Schneider Electric.
4. TORK.
5. Watt Stopper (The).

B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Rating: 30-A inductive or resistive, 600-V ac.
2. Programs: 8 channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
4. Astronomic Time: All channels.
5. Battery Backup: For schedules and time clock.

2.2 OUTDOOR PHOTOLELECTRIC SWITCHES

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. Intermatic, Inc.
2. Novitas, Inc.
3. Square D; Schneider Electric.
4. TORK.
5. Watt Stopper (The).

B. Description: Solid state, with DPST dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.
1. Light-Level Monitoring Range: 1.5 to 10 fc, with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.

2.3 INDOOR OCCUPANCY SENSORS

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. Hubbell Lighting.
3. Lithonia Lighting; Acuity Lighting Group, Inc.
4. Novitas, Inc.
5. Sensor Switch, Inc.
6. TORK.
7. Watt Stopper (The).

B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. 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.
5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.

C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.

1. Detector Sensitivity: Detect occurrences of 6-inch-minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. when mounted on a 96-inch-high ceiling.
3. Detection Coverage (Corridor): Detect occupancy within 90 feet when mounted on a 10-foot-high ceiling.
D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.

1. Detector Sensitivity: 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.
2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. when mounted on a 96-inch-high ceiling.
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 (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. when mounted on a 96-inch-high ceiling.
5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet when mounted on a 10-foot-high ceiling in a corridor not wider than 14 feet.

E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.

1. Sensitivity Adjustment: Separate for each sensing technology.
2. Detector Sensitivity: Detect occurrences of 6-inch-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.

2.4 LIGHTING CONTACTORS

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. ASCO Power Technologies, LP; a division of Emerson Electric Co.
2. Eaton Electrical Inc.; Cutler-Hammer Products.
3. GE Industrial Systems; Total Lighting Control.
4. Square D; Schneider Electric.
5. TORK.
6. Watt Stopper (The).

B. Description: Electrically operated and electrically held combination type with non-fused disconnect, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.
C. DCIM Interface: Provide hardware interface to enable the DCIM to monitor and control lighting contactors.
   1. Monitoring: On-off status
   2. Control: On-off operation

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 Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTACTOR INSTALLATION

A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors.
2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

B. Label time switches and contactors with a unique designation.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify operation of each lighting control device, and adjust time delays.

B. Lighting control devices that fail tests and inspections are defective work.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.7 DEMONSTRATION

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

END OF SECTION 26 09 23
SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.

1.3 SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.


C. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control test reports.
E. Operation and Maintenance Data: For transformers to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7.

B. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Transformers shall be of the same manufacturer as the UPS and Generator switchgear. Subject to compliance with requirements, provide products by one of the following:

1. Square D
2. Eaton
2.2 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.
   1. Internal Coil Connections: Brazed or pressure type.
   2. Coil Material: Copper.

2.3 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2.
   1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.
   1. Finish Color: Gray.

F. Taps for Transformers Smaller than 3 kVA: None.

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:
   1. Complying with NEMA TP 1, Class 1 efficiency levels.
   2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
   1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
   2. Indicate value of K-factor on transformer nameplate.
L. Wall Brackets: Manufacturer's standard brackets.

M. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.4 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification for Electrical Systems."

2.5 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

   1. Brace wall-mounting transformers as specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems.

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
3.3 CONNECTIONS
   A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL
   A. Perform tests and inspections and prepare test reports.
      1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
   B. Tests and Inspections:
      1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
      2. Perform the infrared scan tests and inspections and prepare reports as stated in Section 26 05 00 "Common Work Results for Electrical".
   C. Remove and replace units that do not pass tests or inspections and retest as specified above.
   D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.5 ADJUSTING
   A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
   B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

3.6 CLEANING
   A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 22 00
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. SVR: Suppressed voltage rating.
B. TVSS: Transient voltage surge suppressor.

1.4 PERFORMANCE REQUIREMENTS
A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS
A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
B. Shop Drawings: For each panelboard and related equipment.
   1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
   2. Detail enclosure types and details for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. 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.

E. Panelboard Schedules: For installation in panelboards.

F. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. 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.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

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

C. Comply with NEMA PB 1.

D. Comply with NFPA 70.

1.7 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.
1.8 PROJECT CONDITIONS

A. Environmental Limitations:
   1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 23°F to plus 104°F.
      b. Altitude: Not exceeding 6600 feet.

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
   1. Ambient temperatures within limits specified.
   2. Altitude not exceeding 6600 feet.

1.9 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, 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 in Division 03.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

1.11 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. Keys: Two spares for each type of panelboard cabinet lock.
   2. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.
   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.
PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Panelboards shall be of the same manufacturer as the UPS and Generator switchgear. Subject to compliance with requirements, provide products by one of the following:

1. Square D
2. Eaton

2.2 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted 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 3R.
   c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

3. 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.


C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses:

2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads. Refer to plans where required.
4. Split Bus: Vertical buses divided into individual vertical sections.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

2. Main and Neutral Lugs: Mechanical type.
3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.


2.3 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches high, provide two latches, keyed alike.

C. Mains: See plans.


E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: See plans.

C. Branch Overcurrent Protective Devices: Plug-in circuit breakers, replaceable without disturbing adjacent units.

D. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

E. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.5 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.


3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.

4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.

5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).


8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   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. Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
   e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
   f. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
   g. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
   h. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
   i. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function with other upstream or downstream devices.
   j. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
   k. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.

2.6 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
B. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Receive, inspect, handle, and store panelboards according to NEMA PB 1.1.

B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.

C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Equipment Mounting: Install panelboards on concrete bases, 4-inch nominal thickness. Comply with requirements for concrete base specified in Division 03.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For panelboards, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to panelboards.
5. Attach panelboard to the vertical finished or structural surface behind the panelboard.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from panelboards.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Mount top of trim to ensure the operating handle of top-most switch or circuit breaker, in on position, is not higher than 79 inches above finished floor or grade.

F. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

G. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

H. Install filler plates in unused spaces.
I. 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.

J. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

K. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. 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 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 infrared scan tests and inspections and prepare reports as stated in Section 26 05 00 "Common Work Results for Electrical".

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. Include notation of deficiencies detected, remedial action taken and observations after remedial action.

3.5 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

3.6 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16
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. This Section includes the following:
   1. Receptacles, receptacles with integral GFCI, and associated device plates.
   2. Twist-locking receptacles.
   3. Snap switches and wall-box dimmers.
   4. Pendant cord-connector devices.
   5. Cord and plug sets.
   6. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 RELATED SECTIONS
A. Section 26 09 23 - Lighting Control Devices

1.4 DEFINITIONS
A. EMI: Electromagnetic interference.
B. GFCI: Ground-fault circuit interrupter.
C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
D. RFI: Radio-frequency interference.
E. TVSS: Transient voltage surge suppressor.
F. UTP: Unshielded twisted pair.

1.5 SUBMITTALS
A. Product Data: For each type of product indicated.
B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
C. Field quality-control test reports.

D. Operation and Maintenance Data: For wiring devices to include in all manufacturers’ packing label warnings and instruction manuals that include labeling conditions.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.7 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1. Cord and Plug Sets: Match equipment requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

2.3 GFCI RECEPTACLES

A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
2.4  TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

2.5  PENDANT CORD-CONNECTOR DEVICES

A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
   2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.6  CORD AND PLUG SETS

A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
   1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2.7  SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

C. Pilot Light Switches, 20 A:
   1. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:
   1. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.
2.8 WALL-BOX DIMMERS
A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
B. Control: Continuously adjustable toggle switch with slider; with single-pole or three-way switching. Comply with UL 1472.
C. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.9 WALL PLATES
A. Single and combination types to match corresponding wiring devices.
   1. Plate-Securing Screws: Metal with head color to match plate finish.
B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.10 FLOOR SERVICE FITTINGS
A. Refer to plans.

2.11 POKE-THROUGH ASSEMBLIES
A. Refer to plans

2.12 FINISHES
A. Color: Wiring device catalog numbers in Section Text do not designate 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.

PART 3 - EXECUTION

3.1 INSTALLATION
A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
B. Coordination with Other Trades:
1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up and on horizontally mounted receptacles to the right.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

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 to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."
   1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.
   1. Test Instruments: Use instruments that comply with UL 1436.
   2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:
   1. Line Voltage: Acceptable range is 105 to 132 V.
   2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
   3. Ground Impedance: Values of up to 2 ohms are acceptable.
   4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
   5. Using the test plug, verify that the device and its outlet box are securely mounted.
   6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Test straight blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

END OF SECTION 26 27 26
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 control circuits, and enclosed switches.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

   a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.

   b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.


4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

5. Coordination charts and tables and related data.

6. Fuse sizes for elevator feeders and elevator disconnect switches.

B. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Ambient temperature adjustment information.

2. Current-limitation curves for fuses with current-limiting characteristics.

3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.

4. Coordination charts and tables and related data.
1.4 QUALITY ASSURANCE
   A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.
   B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   C. Comply with NEMA FU 1 for cartridge fuses.
   D. Comply with NFPA 70.
   E. Comply with UL 248-11 for plug fuses.

1.5 PROJECT CONDITIONS
   A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.6 COORDINATION
   A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS
   A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      1. Cooper Bussmann, Inc.
      2. Edison Fuse, Inc.
      3. Ferraz Shawmut, Inc.
      4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES
   A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.
PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Cartridge Fuses:
   1. Motor Branch Circuits: Class RK1, time delay.
   2. Other Branch Circuits: Class RK1, time delay.
   3. Control Circuits: Class CC.

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 Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13
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. Shunt trip switches.
   4. Molded-case circuit breakers (MCCBs).
   5. Molded-case switches.

1.3 RELATED SECTIONS

A. Section 26 24 16 - Panelboards

1.4 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".


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SECTION 26 28 16
ENCLOSED SWITCHES AND CIRCUIT BREAKERS

26 28 16 - 1
ENCLOSED SWITCHES AND CIRCUIT BREAKERS
1.6 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.

C. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. 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.

E. Manufacturer's field service report.

F. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.7 QUALITY ASSURANCE

A. 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.

1.8 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than -22°F and not exceeding 104°F.
   2. Altitude: Not exceeding 6600 feet.

1.9 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 MANUFACTURERS

A. Manufacturers: Enclosed switches and circuit breakers shall be of the same manufacturer as the UPS and Generator switchgear. Subject to compliance with requirements, provide products by one of the following:
   1. Square D
   2. Eaton

2.2 FUSIBLE SWITCHES

A. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

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. Type HD, Heavy Duty, Double 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.

D. Accessories:
1. **Equipment Ground Kit:** Internally mounted and labeled for copper and aluminum ground conductors.
2. **Neutral Kit:** Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. **Class R Fuse Kit:** Provides rejection of other fuse types when Class R fuses are specified.
4. **Lugs:** Mechanical type, suitable for number, size, and conductor material.
5. **Service-Rated Switches:** Labeled for use as service equipment.

### 2.3 NONFUSIBLE SWITCHES

**A.** Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

**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.** Type HD, Heavy Duty, Double 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.

**D.** Accessories:

1. **Equipment Ground Kit:** Internally mounted and labeled for copper and aluminum ground conductors.
2. **Neutral Kit:** Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
3. **Lugs:** Mechanical type, suitable for number, size, and conductor material.

### 2.4 MOLDED-CASE CIRCUIT BREAKERS

**A.** Refer to Section 26 24 16 - Panelboards.

### 2.5 ENCLOSURES

**A.** Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. **Indoor, Dry and Clean Locations:** NEMA 250, Type 1.
2. **Outdoor Locations:** NEMA 250, Type 3R.
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. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in fusible devices.

E. Comply with NECA 1.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "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 infrared scan tests and inspections and prepare reports as stated in Section 26 05 00 “Common Work Results for Electrical”.
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.

B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

END OF SECTION 26 28 16
SECTION 26 29 13

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes ac, enclosed controllers rated 600 V and less, of the following types:

1. Across-the-line, manual and magnetic controllers.
2. Reduced-voltage controllers.

1.3 SUBMITTALS

A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each enclosed controller.

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. Include the following:

   a. Each installed unit's type and details.
   b. Nameplate legends.
   c. Short-circuit current rating of integrated unit.
   d. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that enclosed controllers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems" Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Field quality-control test reports.

F. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for enclosed controllers and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed controllers of a single type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.6 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

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. Indicating Lights: Two of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Enclosed controllers shall be of the same manufacturer as the UPS and Generator switchgear. Subject to compliance with requirements, provide products by one of the following:

1. Square D
2. Eaton

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Provide with heaters or sensors in each
C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.

1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.

2.3 REDUCED-VOLTAGE ENCLOSED CONTROLLERS

A. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay.
C. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition.
D. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
3. LED indicators showing motor and control status, including the following conditions:
   a. Control power available.
   b. Controller on.
   c. Overload trip.
   d. Loss of phase.
   e. Shorted silicon-controlled rectifier.

2.4 ENCLOSURES

A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.
2. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2.5 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

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REES Project #21503.00
Brinjac Project #15.00493.80
C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Elapsed Time Meters: Heavy duty with digital readout in hours.


2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard Gray paint applied to factory-assembled and -tested enclosed controllers before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

B. Install freestanding equipment on concrete bases.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."
3.4 CONCRETE BASES
   A. Coordinate size and location of concrete bases. Verify structural requirements with structural
      engineer.
   B. Concrete base is specified in Division 26 Section "Hangers and Supports for Electrical
      Systems," and concrete materials and installation requirements are specified in Division 03.

3.5 IDENTIFICATION
   A. Identify enclosed controller, components, and control wiring according to Division 26 Section
      "Identification for Electrical Systems."

3.6 CONTROL WIRING INSTALLATION
   A. Install wiring between enclosed controllers according to Division 26 Section "Low-Voltage
      Electrical Power Conductors and Cables."
   B. Bundle, train, and support wiring in enclosures.
   C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
      1. Connect selector switches to bypass only manual- and automatic-control devices that
         have no safety functions when switch is in hand position.
      2. Connect selector switches with enclosed controller circuit in both hand and automatic
         positions for safety-type control devices such as low- and high-pressure cutouts,
         high-temperature cutouts, and motor overload protectors.

3.7 CONNECTIONS
   A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate
      general arrangement of conduit, fittings, and specialties.
   B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical
      Systems."

3.8 FIELD QUALITY CONTROL
   A. Prepare for acceptance tests as follows:
      1. Test insulation resistance for each enclosed controller element, bus, component,
         connecting supply, feeder, and control circuit.
      2. Test continuity of each circuit.
   B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform
      the following:
      1. Inspect controllers, wiring, components, connections, and equipment installation.
      2. Assist in field testing of equipment.
C. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. 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 infrared scan tests and inspections and prepare reports as stated in Section 26 05 00 “Common Work Results for Electrical”.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

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

END OF SECTION 26 29 13
PART 1 - GENERAL

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

1.2 SUMMARY
A. This Section includes the following:
   1. Interior lighting fixtures, lamps, and ballasts.
   2. Emergency lighting units.
   3. Exit signs.
   4. Lighting fixture supports.
B. Related Sections include the following:
   1. Section 26 09 23 – "Lighting Control Devices" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
   2. Section 26 27 26 - "Wiring Devices" for manual wall-box dimmers.

1.3 DEFINITIONS
A. BF: Ballast factor.
B. CRI: Color-rendering index.
C. CU: Coefficient of utilization.
D. HID: High-intensity discharge.
E. LER: Luminaire efficacy rating.
F. Luminaire: Complete lighting fixture, including ballast housing if provided.
G. RCR: Room cavity ratio.

1.4 SUBMITTALS
A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:
1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
5. Life, output, and energy-efficiency data for lamps.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

D. Warranties: Special warranties specified in this Section.

1.5 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70.

1.6 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.7 WARRANTY

A. Special Warranty for Ballasts: Manufacturer's standard form in which ballast manufacturer agrees to repair or replace ballasts that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Electronic Ballasts: Five years from date of Substantial Completion.

B. Special Warranty for T5 and T8 Fluorescent Lamps: Manufacturer's standard form, made out to Owner and signed by lamp manufacturer agreeing to replace lamps that fail in materials or workmanship, f.o.b. the nearest shipping point to Project site, within specified warranty period indicated below.

1. Warranty Period: One year(s) from date of Substantial Completion.
1.8 EXTRA MATERIALS

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

1. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Plastic Diffusers and Lenses: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Battery and Charger Data: One for each emergency lighting unit.
4. Ballasts: 1 for every 100 of each type and rating installed. Furnish at least one of each type.
5. Globes and Guards: 1 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Interior Lighting Fixture Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

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

2.2 LIGHTING FIXTURES AND COMPONENTS, GENERAL REQUIREMENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Fluorescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.

D. HID Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5B.

E. Metal Parts: Free of burrs and sharp corners and edges.

F. Sheet Metal Components: Steel, unless otherwise indicated. Form and support to prevent warping and sagging.

G. 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.

H. 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.
4. Laminated Silver Metallized Film: 90 percent.

I. Electromagnetic-Interference Filters: Factory installed to suppress conducted electromagnetic-interference as required by MIL-STD-461E. Fabricate lighting fixtures with one filter on each ballast indicated to require a filter.

2.3 BALLASTS FOR LINEAR FLUORESCENT LAMPS

A. Electronic Ballasts: Comply with ANSI C82.11; programmed-start type, unless otherwise indicated, and designed for type and quantity of lamps served. Ballasts shall be designed for full light output unless dimmer or bi-level control is indicated.

1. Sound Rating: A.
2. Total Harmonic Distortion Rating: Less than 10 percent.
3. Transient Voltage Protection: IEEE C62.41, Category A or better.
4. Operating Frequency: 20 kHz or higher.
5. Lamp Current Crest Factor: 1.7 or less.
6. BF: 0.85 or higher.
7. Power Factor: 0.95 or higher.
8. Parallel Lamp Circuits: Multiple lamp ballasts shall comply with ANSI C 82.11 and shall be connected to maintain full light output on surviving lamps if one or more lamps fail.

B. Electronic Programmed-Start Ballasts for T5 and T5HO Lamps: Comply with ANSI C82.11 and the following:

1. Lamp end-of-life detection and shutdown circuit for T5 diameter lamps.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: 0.95 or higher.

C. Ballasts for Low-Temperature Environments:

1. Temperatures 0°F and Higher: Electronic type rated for 0°F starting and operating temperature with indicated lamp types.
2. Temperatures -20°F and Higher: Electromagnetic type designed for use with indicated lamp types.

D. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.
2.4 BALLASTS FOR COMPACT FLUORESCENT LAMPS

A. Description: Electronic programmed rapid-start type, complying with ANSI C 82.11, designed for type and quantity of lamps indicated. Ballast shall be designed for full light output unless dimmer or bi-level control is indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Automatic lamp starting after lamp replacement.
3. Sound Rating: A.
4. Total Harmonic Distortion Rating: Less than 20 percent.
5. Transient Voltage Protection: IEEE C62.41, Category A or better.
6. Operating Frequency: 20 kHz or higher.
7. Lamp Current Crest Factor: 1.7 or less.
8. BF: 0.95 or higher, unless otherwise indicated.
9. Power Factor: 0.95 or higher.
10. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.

B. Ballasts for Dimmer-Controlled Lighting Fixtures: Electronic type.

1. Dimming Range: 100 to 5 percent of rated lamp lumens.
2. Ballast Input Watts: Can be reduced to 20 percent of normal.
3. Compatibility: Certified by manufacturer for use with specific dimming control system and lamp type indicated.

2.5 EMERGENCY FLUORESCENT POWER UNIT

A. Internal Type: Self-contained, modular, battery-inverter unit, factory mounted within lighting fixture body and compatible with ballast. Comply with UL 924.

1. Emergency Connection: Operate 1 fluorescent lamp(s) continuously at an output of 1100 lumens each. Connect unswitched circuit to battery-inverter unit and switched circuit to fixture ballast.
2. Test Push Button and Indicator Light: Visible and accessible without opening fixture 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.
5. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and flashing red LED.
2.6 BALLASTS FOR HID LAMPS

A. Electronic Ballast for Metal-Halide Lamps: Include the following features unless otherwise indicated:

1. Lamp end-of-life detection and shutdown circuit.
2. Sound Rating: A.
3. Total Harmonic Distortion Rating: Less than 15 percent.
4. Transient Voltage Protection: IEEE C62.41, Category A or better.
5. Lamp Current Crest Factor: 1.5 or less.
6. Power Factor: .90 or higher.
7. Interference: Comply with 47 CFR, Chapter 1, Part 18, Subpart C, for limitations on electromagnetic and radio-frequency interference for nonconsumer equipment.
8. Protection: Class P thermal cutout.
9. Retain subparagraph and associated subparagraphs below for bi-level ballasts.

2.7 FLUORESCENT LAMPS

A. Low-Mercury Lamps: Comply with EPA’s toxicity characteristic leaching procedure test; shall yield less than 0.2 mg of mercury per liter when tested according to NEMA LL 1.

B. T8 rapid-start low-mercury lamps, rated 32 W maximum, nominal length of 48 inches, 2800 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life 20,000 hours, unless otherwise indicated.

C. T8 rapid-start low-mercury lamps, rated 17 W maximum, nominal length of 24 inches, 1300 initial lumens (minimum), CRI 75 (minimum), color temperature 3500K, and average rated life of 20,000 hours, unless otherwise indicated.

D. T5 rapid-start low-mercury lamps, rated 28 W maximum, nominal length of 45.2 inches 2900 initial lumens (minimum), CRI 85 (minimum), color temperature 3500K, and average rated life of 20,000 hours, unless otherwise indicated.

E. T5HO rapid-start, high-output low-mercury lamps, rated 54 W maximum, nominal length of 45.2 inches, 5000 initial lumens (minimum), CRI 85 (minimum), color temperature 3500K, and average rated life of 20,000 hours, unless otherwise indicated.

F. Compact Fluorescent Lamps: 4-Pin, low mercury, CRI 80 (minimum), color temperature 3500 K, average rated life of 10,000 hours at 3 hours operation per start, and suitable for use with dimming ballasts, unless otherwise indicated.

1. 13 W: T4, double or triple tube, rated 900 initial lumens (minimum).
2. 18 W: T4, double or triple tube, rated 1200 initial lumens (minimum).
3. 26 W: T4, double or triple tube, rated 1800 initial lumens (minimum).
4. 32 W: T4, triple tube, rated 2400 initial lumens (minimum).
5. 42 W: T4, triple tube, rated 3200 initial lumens (minimum).

2.8 HID LAMPS

A. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000K.
2.9 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "Hangers and Supports for Electrical Systems" for channel- and angle-iron supports and nonmetallic channel and angle supports.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.


E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

F. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lighting fixtures: Set level, plumb, and square with ceilings and walls. Install lamps in each fixture.

B. Support for Lighting Fixtures in or on Grid-Type Suspended Ceilings: Use grid as a support element.
   1. Install a minimum of four ceiling support system rods or wires for each fixture. Locate not more than 6 inches from lighting fixture corners.
   2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
   3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.
   4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

C. Suspended Lighting Fixture Support:
   1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
   3. Continuous Rows: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of fixture chassis, including one at each end.

D. Air-Handling Lighting Fixtures: Install with dampers closed and ready for adjustment.

E. Adjust aimable lighting fixtures to provide required light intensities.
F. Connect wiring according to Division 26 Section “Low-Voltage Electrical Power Conductors and Cables.”

3.2 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION 26 51 00
SECTION 26 56 00
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. This Section includes the following:
   1. Exterior luminaires with lamps and ballasts.
   2. Poles and accessories.
B. Related Sections include the following:
   1. Section 26 51 00 - "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 DEFINITIONS
A. CRI: Color-rendering index.
B. HID: High-intensity discharge.
C. Luminaire: Complete lighting fixture, including ballast housing if provided.
D. Pole: Luminaire support structure, including tower used for large area illumination.
E. Standard: Same definition as "Pole" above.

1.4 SUBMITTALS
A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:
   1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
   2. Details of attaching luminaires and accessories.
   3. Details of installation and construction.
   4. Luminaire materials.
5. Photoelectric relays.
6. Ballasts, including energy-efficiency data.
7. Lamps, including life, output, and energy-efficiency data.
8. Materials, dimensions, and finishes of poles.
9. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
10. Anchor bolts for poles.

B. Field quality-control test reports.

C. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

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.


C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch deep. Do not apply tools to section of pole to be installed below ground line.

D. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

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. Lamps: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: 10 for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: 10 for every 20 of each type and rating installed. Furnish at least one of each type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In Exterior Lighting Device Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

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

2.2 LUMINAIRES, GENERAL REQUIREMENTS

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

B. Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum, unless otherwise indicated. Form and support to prevent warping and sagging.

E. housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.
K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

2.3 FLUORESCENT BALLASTS AND LAMPS

A. Low-Temperature Ballast Capability: Rated by its manufacturer for reliable starting and operation of indicated lamp(s) at temperatures -20°F and higher.

B. Ballast Characteristics:
   1. Power Factor: 90 percent, minimum.
   2. Sound Rating: A.
   3. Total Harmonic Distortion Rating: Less than 10 percent.
   6. Transient-Voltage Protection: Comply with IEEE C62.41 Category A or better.

C. Low-Temperature Lamp Capability: Rated for reliable starting and operation with ballast provided at temperatures -20°F and higher.

D. Fluorescent Lamps: refer to Section 26 51 00 – Interior Lighting

2.4 BALLASTS FOR HID LAMPS

A. Comply with ANSI C82.4 and UL 1029 and capable of open-circuit operation without reduction of average lamp life. Include the following features, unless otherwise indicated:
   1. Ballast Circuit: Constant-wattage autotransformer or regulating high-power-factor type.
   2. Minimum Starting Temperature: -22°F.
   3. Normal Ambient Operating Temperature: 104°F.
   4. Ballast Fuses: One in each ungrounded power supply conductor. Voltage and current ratings as recommended by ballast manufacturer.

2.5 HID LAMPS

A. Pulse-Start, Metal-Halide Lamps: Minimum CRI 65, and color temperature 4000K.

2.6 POLES AND SUPPORT COMPONENTS, GENERAL REQUIREMENTS

A. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.
   1. Materials: Shall not cause galvanic action at contact points.
   2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication, unless stainless-steel items are indicated.
   3. Anchor-Bolt Template: Plywood or steel.
B. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-Place Concrete."

2.7 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Division 26 Section "Wiring Devices" for ground-fault circuit-interrupter type.

1. Recessed, 12 inches above finished grade.
2. Nonmetallic polycarbonate plastic or reinforced fiberglass cover that when mounted results in NEMA 250, Type 3R enclosure.
3. With cord opening.
4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

B. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03 Section "Cast-in-Place Concrete."

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch-thick, pipe-wrapping plastic tape applied with a 50 percent overlap.
3.4 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."
   1. Install grounding electrode for each pole, unless otherwise indicated.
   2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.
   1. Verify operation of photoelectric controls.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

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

END OF SECTION 26 56 00
# SPECIFICATION INDEX

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SECTION 27 05 00
COMMON WORK RESULTS FOR COMMUNICATIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. Drawings 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. Communications equipment coordination and installation.
   2. Common communications installation requirements.

B. Related Sections:
   1. Section 26 05 00 – Common Work Results for Electrical
   2. Section 28 05 00 – Common Work Results for Electronic Safety and Security

1.3 DEFINITIONS
A. EPDM: Ethylene-propylene-diene terpolymer rubber.
B. NBR: Acrylonitrile-butadiene rubber.

1.4 COORDINATION
A. Coordinate arrangement, mounting, and support of communications equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting pathways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping.""

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

2.2 GROUT
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION
   A. Comply with NECA 1.
   B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
   C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
   D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
   E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION - FOR COMMUNICATIONS PENETRATIONS
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

3.3 FIRESTOPPING
   A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 27 05 00
SECTION 27 11 00

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

   1. Telecommunications mounting elements.
   2. Backboards.
   3. Telecommunications service entrance pathways.

B. Related Sections:

   1. Section 26 05 26 – Grounding and Bonding for Electrical Systems

1.3 DEFINITIONS


B. LAN: Local area network.

C. RCDD: Registered Communications Distribution Designer.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects
   of earthquake motions determined according to SEI/ASCE 7.

   1. The term "withstand" means "the unit will remain in place without separation of any parts
      from the device when subjected to the seismic forces specified and the unit will be fully
      operational after the seismic event".

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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.7 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner’s telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, J-hooks, and D-rings.
4. Straps and other devices.

C. Cable Trays: Comply with requirements in Section 26 05 36 – Cable Trays for Electrical Systems.

D. Conduit and Boxes: Comply with requirements in Section 26 05 33 – Raceway and Boxes for Electrical Systems.
2.2 BACKBOARDS
   A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry."

2.3 GROUNDING
   A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
   B. Comply with ANSI-J-STD-607-A.

2.4 LABELING
   A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES
   A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
   B. Install underground entrance pathway complying with Division 26 Section "Raceway and Boxes for Electrical Systems.

3.2 INSTALLATION
   A. Comply with NECA 1.
   B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
   D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 FIRESTOPPING
   A. Comply with requirements in Division 07 Section "Penetration Firestopping."Comply with TIA/EIA-569-A, Annex A, "Firestopping."
   B. Comply with BICSI TDMM, "Firestopping Systems" Article.
3.4 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Section 26 05 53 – Identification for Electrical Systems. For fire-resistant plywood, do not paint over manufacturer’s label.

B. Labels shall be preprinted or computer-printed type.

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SECTION 28 05 00
COMMON WORK RESULTS 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. Electronic safety and security equipment coordination and installation.
   2. Common electronic safety and security installation requirements.

B. Related Sections:
   1. Section 26 05 00 – Common Work Results for Electrical
   2. Section 27 05 00 – Common Work Results For Communications

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 COORDINATION

A. Coordinate arrangement, mounting, and support of electronic safety and security equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electronic safety and security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

2.2 GROUT
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATION
   A. Comply with NECA 1.
   B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
   C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
   D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
   E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

3.3 FIRESTOPPING
   A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 28 05 00
SECTION 28 31 11

DIGITAL ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
3. System smoke detectors.
8. Addressable interface device.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

1.4 SYSTEM DESCRIPTION

A. Non-coded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".

B. Contractor to coordinate the monitoring obligation of the fire alarm system. The Contractor is responsible for the monitoring of the fire alarm system 90 days after the substantial completion.
The fire alarm system shall remain code compliant after the monitoring obligations of the contractor are turned over to BBBY.

C. Contractor to provide the monitoring forms with the following information:

1. Monitoring company’s name
2. Monitoring company’s contact telephone numbers
3. Monitoring account number for this facility
4. Call list that includes the Manager and any other contacts designated by BBBY to provide the appropriate contact information to the contractor for completion of this form.

1.6 SUBMITTALS

A. 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.

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

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Qualification Data: For qualified Installer.

E. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Field quality-control reports.

G. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
   a. Frequency of testing of installed components.
   b. Frequency of inspection of installed components.
   c. Requirements and recommendations related to results of maintenance.
   d. Manufacturer's user training manuals.
5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

H. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 PROJECT RECORD DOCUMENTS

A. The Contractor shall provide and maintain on site an up-to-date record set of approved shop drawing prints which shall be marked to show each and every change made to the fire alarm system from the original approved shop drawings. This shall not be construed as authorization to deviate from or make changes to the shop drawings approved by the Engineer without written instructions from the Engineer in each case. This set of drawings shall be issued only as a record set. These drawings shall be made available to the Owner, or the Owner's Representative, upon request.

B. The Contractor shall continually document software and programming changes. This documentation shall include:

1. A complete printout of the system prior to the change.
2. A complete printout of the system program subsequent to the change, with all modifications highlighted.
3. A letter prepared and signed by the individual who made the changes, describing each change made and the reason for the change. This letter shall certify that the programmer has personally reviewed and compared the before and after program printout and verified the correctness of the modification(s).

4. An equivalent means performed automatically in computer software, which verified the results of changes made is acceptable.

C. Once the fire alarm system is put into service, in whole or in part, and the associated building(s) are partially or wholly occupied, no software changes shall be performed without prior written permission of the Owner, or Owner’s Representative.

D. Only a certified manufacturer’s representative trained in the specific programming software shall make changes to the fire alarm system software once the system is in service.

E. Each revision to the software shall be identified by a unique version number and date.

F. The Contractor shall include sufficient labor for one (1) complete system reprogramming. This allotted reprogramming time shall be conducted for changes after project conditions, system interconnections, and required text are finalized and reviewed by the Engineer. Provide unit pricing for each additional reprogramming.

G. Prior to final payment for the fire alarm system and the beginning of the warranty period, submit the following completed project record documents to the Owner’s Representative:

1. Copies of all test and inspection reports as required by the AHJ and NFPA 72:
   a. The Record of Completion form shall be in the format as outlined in NFPA 72.
   b. The Inspection and Testing form shall be in the format as outlined in NFPA 72.

2. All permits and licenses required to be in the possession of the Owner by the AHJ.

3. Accurate record (as-built) drawings of the complete installation to include, but not be limited to, the information required for the shop drawings. Record drawings of the floor plans shall be AutoCAD generated.

4. A complete copy of the fire alarm system’s software program including, but not limited to, the device information, software zone and control function parameters.

5. A list of passwords required, to operate the fire alarm system including any passwords to enable, disable or bypass a device or function.

6. Original warranty documents including, but not limited to, those of the FAEM. Warranty documents shall reference and be binding to the warranty provisions specified in the warrant portion of this specification.

7. Submit to the Engineer a copy of the transmittal to the Owner’s Representative for all final complete project record documents.

H. Upon completion of construction, submit three (3) sets of equipment warranties and three (3) sets of installation, operations and maintenance instructions to the Owner’s Representative. This manual shall reflect the completed installation and include, but not be limited to the following information:

1. A detailed narrative description of the systems architecture, inputs, evacuation signaling, auxiliary functions, annunciation, sequence of operation, expansion capability, application considerations and limitations.

2. A detailed description of routine maintenance required or recommended, or as would be provided under a maintenance contract, including a testing schedule and detailed maintenance instructions for each type of device installed.

3. Detailed troubleshooting instructions for each possible trouble condition.
4. An equipment list/schedule detailing all equipment and quantities installed. The manufacturer’s product model/identification number shall be shown next to each piece of equipment on the list.

5. Updated manufacturer’s data sheets and installation manuals/instructions for all equipment installed.

6. A detailed description of the operation of the systems, including operator responses. Copies of the approved sequence of operation shall be placed in, or adjacent to the control panel.

I. A copy of all software documentation required by this section shall be maintained on-site by the Contractor, in a binder, arranged in chronological order. This binder shall be provided to the Owner's Representative at the completion of the project.

J. Contractor to leave a CD copy of the fire alarm restore with instruction guide in cabinet 'A' located near the power wall.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no less than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no less than 1 unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no less than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no less than 1 unit of each type.
5. Keys and Tools: One extra set for access to lock and tamperproof components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Fire Lite Alarms; a Honeywell company.
   2. NOTIFIER; a Honeywell company.
   3. SimplexGrinnell LP; a Tyco International company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
   2. Heat detectors.
   3. Smoke detectors.
   4. Duct smoke detectors.
   5. Verified automatic alarm operation of smoke detectors.
   6. Automatic sprinkler system water flow.
   7. Heat detectors in elevator shaft and pit.
   8. Fire-extinguishing system operation.
   9. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:
   1. Continuously operate alarm notification appliances.
   2. Identify alarm at fire-alarm control unit and remote annunciators.
   3. Transmit an alarm signal to the remote alarm receiving station.
   4. Unlock electric door locks and exterior gates 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. Activate stairwell and elevator-shaft pressurization systems.
   9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
  10. Recall elevators to primary or alternate recall floors.
  11. Activate emergency shutoffs for gas and fuel supplies.
  12. Record events in the system memory.
C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory/tamper switch.
2. Low-air-pressure switch of a dry-pipe sprinkler system.
3. Elevator shunt-trip supervision.

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 primary power at fire-alarm control unit.
4. Ground or a single break in fire-alarm control unit internal circuits.
5. Abnormal ac voltage at fire-alarm control unit.
7. Failure of battery charging.
8. Abnormal position of any switch at fire-alarm control unit or annunciator.
9. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
   a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
   b. Include a real-time clock for time annotation of events on the event recorder and printer.

2. Addressable initiation devices that communicate device identity and status.
   a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
   b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.

3. Addressable control circuits for operation of mechanical equipment.

B. 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, 3 lines 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.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   a. Initiating Device Circuits: Style D.
   b. Notification Appliance Circuits: Style Z.
   d. Install no more than 50 addressable devices on each signaling line circuit.


D. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall.
   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 lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.

3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
   a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

E. 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.

F. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

G. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

H. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.

1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
a. Allow the application of and evacuation signal to indicated number of zones and, at
same time, allow voice paging to the other zones selectively or in any combination.
b. Programmable tone and message sequence selection.
c. Standard digitally recorded messages for "Evacuation" and "All Clear."
d. Generate tones to be sequenced with audio messages of type recommended by
NFPA 72 and that are compatible with tone patterns of notification appliance
circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the
status of firefighters' two-way telephone communication zones.

3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units,
on primary equipment failure.

I. 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 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 powersupply module rating.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and
automatic transfer switch.


2.4 MANUAL FIRE-ALARM BOXES

A. 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. Single-action mechanism, pull-lever type; with integral addressable module arranged to
communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to
permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-
powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the
top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. 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 analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
   - **a.** Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15°F or 20°F per minute.
   - **b.** Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135°F or 155°F.
   - **c.** Provide multiple levels of detection sensitivity for each sensor.

8. **Remote Control:** Provide an automatic test feature to permit functional testing of the device from the main control panel. Indicate results of the test on the LCD display.

**B. 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.).

**C. Ionization Smoke Detector:**

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   - **a.** Primary status.
   - **b.** Device type.
   - **c.** Present average value.
   - **d.** Present sensitivity selected.
   - **e.** Sensor range (normal, dirty, etc.).

**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. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

E. Aspirating Smoke Detector
1. The Aspirating Smoke Detector (ASD) shall offer Very Early Warning Smoke Detection, Early Warning Smoke Detection and Standard Smoke Detection settings. The sensitivity range shall be from 0.00046%/ft – 4.0%/ft. Operating temperatures shall be from 32°F to 100°F. Sampled air temperatures shall range from –4° to 140°F. Operating humidity shall range from 10-95% non-condensing. The ASD shall have dual source (blue LED and infra-red laser) optical smoke detection for a wide range of fire detection with enhanced immunity to nuisance particulates. The ASD shall operate in air flows from 0-4000 ft/min.

2.6 HEAT DETECTORS
A. General Requirements for Heat Detectors: Comply with UL 521.
B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135°F or a rate of rise that exceeds 15°F per minute unless otherwise indicated.
1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES
A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
B. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
C. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
D. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.
E. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
1. Rated Light Output:
   a. 15/30/75/110 cd, selectable in the field.
2. Mounting: Wall or ceiling mounted. Locate on ceiling where possible and approved by local authority having jurisdiction.
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.

F. Voice/Tone Notification Appliances:

1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. High-Range Units: Rated 2 to 15 W.
3. Low-Range Units: Rated 1 to 2 W.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.8 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

2.9 REMOTE ANNUNCIATOR

A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.

1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE

A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.
2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one 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 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.
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 or loss of power.
5. Low battery.
6. Abnormal test signal.
7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 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 manufacturer of device.
2. Finish: Paint of color to match the protected device.

2.13 BACnet COMMUNICATION OUTPUT CARD

A. Provide an output communication card for BACnet protocol communications. The output shall be connected to the Data Center Energy Management System.
PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   1. Comply with requirements for seismic-restraint devices specified in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”

C. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

D. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

E. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

F. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

G. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

H. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

I. Device Location-Indicating Lights: Locate in public space near the device they monitor.

J. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

K. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

L. All fire alarm cabling shall be routed in minimum 1” conduit. Provide larger conduit as required per NEC.

M. The Capillary Sampling Network
   1. Where false ceilings are installed, the sampling pipe shall be installed above the ceiling, and Capillary Sampling Points shall be installed on the ceiling and connected by means of a capillary tube.
   2. The minimum internal diameter of the Capillary tube shall be 5mm, the maximum length of the Capillary tube shall be 2m unless the manufacturer in consultation with the engineer have specified otherwise.
   3. The Capillary tube shall terminate at a Ceiling Sampling Point specifically designed and approved by the manufacturer. The performance characteristics of the Sampling Points shall be taken into account during the system design.
N. Air Sampling Pipe Network Calculations
1. Air Sampling Pipe Network Calculations shall be provided by a sampling pipe aspiration modeling program such as ASPIRE (latest Version; ASPIRE for Windows® Version 2.9.2.). Pipework calculations shall be supplied with the proposed pipe layout design to indicate the following performance criteria:

2. Transport Time
   a. The manufacturer's recommended transport time (time taken for the smoke to enter the pipe and reach the detector) for the least favorable sampling point is 
      60 seconds or less.

   b. Local codes or end users standards may also apply. For example:
      1) NFPA72 US 120 Seconds

3. The maximum transport time must never exceed the local codes.

4. Balance Percent
   a. The sample point balance for the pipe shall not be less than 70% as indicated by ASPIRE. That is, the volume of air drawn from the last sampling point shall not be less than 70% of the average volume of air through the other holes.

5. Share Percent
   a. The sample hole share for the pipe shall not be less than 70% as indicated by ASPIRE. That is, the sum volume of air drawn through the sampling holes must always be greater than 70% of the total volume of air entering the pipe (i.e. the End Vent must not exceed 30% of the total flow).

3.2 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 Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

   1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.

   2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.

   3. Smoke dampers in air ducts of designated air-conditioning duct systems.

   4. Alarm-initiating connection to elevator recall system and components.

   5. Alarm-initiating connection to activate emergency lighting control.

   6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.

   7. Supervisory connections at valve supervisory switches.

   8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.


3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.

a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.

b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.


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.


D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.
3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system for a minimum of eight (8) hours.

END OF SECTION 28 31 11
SECTION 28 05 00
COMMON WORK RESULTS 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. Electronic safety and security equipment coordination and installation.
   2. Common electronic safety and security installation requirements.

B. Related Sections:
   1. Section 26 05 00 – Common Work Results for Electrical
   2. Section 27 05 00 – Common Work Results For Communications

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. NBR: Acrylonitrile-butadiene rubber.

1.4 COORDINATION

A. Coordinate arrangement, mounting, and support of electronic safety and security equipment:
   1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
   2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
   3. To allow right of way for piping and conduit installed at required slope.
   4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electronic safety and security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping.".

PART 2 - PRODUCTS

2.1 SLEEVES FOR PATHWAYS AND CABLES
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

2.2 GROUT
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATION
   A. Comply with NECA 1.
   B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
   C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
   D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
   E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS
   A. Comply with requirements in Section 26 05 00 – Common Work Results for Electrical

3.3 FIRESTOPPING
   A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 28 05 00
SECTION 28 31 11
DIGITAL ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Fire-alarm control unit.
3. System smoke detectors.
8. Addressable interface device.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

1.4 SYSTEM DESCRIPTION

A. Non-coded, UL-certified addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".

B. Contractor to coordinate the monitoring obligation of the fire alarm system. The Contractor is responsible for the monitoring of the fire alarm system 90 days after the substantial completion.
The fire alarm system shall remain code compliant after the monitoring obligations of the contractor are turned over to BBBY.

C. Contractor to provide the monitoring forms with the following information:

1. Monitoring company’s name
2. Monitoring company’s contact telephone numbers
3. Monitoring account number for this facility
4. Call list that includes the Manager and any other contacts designated by BBBY to provide the appropriate contact information to the contractor for completion of this form.

1.6 SUBMITTALS

A. 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.

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

C. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.

2. Include voltage drop calculations for notification appliance circuits.
3. Include battery-size calculations.
4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
6. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
7. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.

D. Qualification Data: For qualified Installer.

E. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Field quality-control reports.

G. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section “Operation and Maintenance Data,” include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
   a. Frequency of testing of installed components.
   b. Frequency of inspection of installed components.
   c. Requirements and recommendations related to results of maintenance.
   d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Copy of NFPA 25.

H. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 PROJECT RECORD DOCUMENTS

A. The Contractor shall provide and maintain on site an up-to-date record set of approved shop drawing prints which shall be marked to show each and every change made to the fire alarm system from the original approved shop drawings. This shall not be construed as authorization to deviate from or make changes to the shop drawings approved by the Engineer without written instructions from the Engineer in each case. This set of drawings shall be issued only as a record set. These drawings shall be made available to the Owner, or the Owner's Representative, upon request.

B. The Contractor shall continually document software and programming changes. This documentation shall include:

1. A complete printout of the system prior to the change.
2. A complete printout of the system program subsequent to the change, with all modifications highlighted.
3. A letter prepared and signed by the individual who made the changes, describing each change made and the reason for the change. This letter shall certify that the programmer has personally reviewed and compared the before and after program printout and verified the correctness of the modification(s).

4. An equivalent means performed automatically in computer software, which verified the results of changes made is acceptable.

C. Once the fire alarm system is put into service, in whole or in part, and the associated building(s) are partially or wholly occupied, no software changes shall be performed without prior written permission of the Owner, or Owner’s Representative.

D. Only a certified manufacturer’s representative trained in the specific programming software shall make changes to the fire alarm system software once the system is in service.

E. Each revision to the software shall be identified by a unique version number and date.

F. The Contractor shall include sufficient labor for one (1) complete system reprogramming. This allotted reprogramming time shall be conducted for changes after project conditions, system interconnections, and required text are finalized and reviewed by the Engineer. Provide unit pricing for each additional reprogramming.

G. Prior to final payment for the fire alarm system and the beginning of the warranty period, submit the following completed project record documents to the Owner’s Representative:

1. Copies of all test and inspection reports as required by the AHJ and NFPA 72:
   a. The Record of Completion form shall be in the format as outlined in NFPA 72.
   b. The Inspection and Testing form shall be in the format as outlined in NFPA 72.
2. All permits and licenses required to be in the possession of the Owner by the AHJ.
3. Accurate record (as-built) drawings of the complete installation to include, but not be limited to, the information required for the shop drawings. Record drawings of the floor plans shall be AutoCAD generated.
4. A complete copy of the fire alarm system’s software program including, but not limited to, the device information, software zone and control function parameters.
5. A list of passwords required, to operate the fire alarm system including any passwords to enable, disable or bypass a device or function.
6. Original warranty documents including, but not limited to, those of the FAEM. Warranty documents shall reference and be binding to the warranty provisions specified in the warrant portion of this specification.
7. Submit to the Engineer a copy of the transmittal to the Owner’s Representative for all final complete project record documents.

H. Upon completion of construction, submit three (3) sets of equipment warranties and three (3) sets of installation, operations and maintenance instructions to the Owner’s Representative. This manual shall reflect the completed installation and include, but not be limited to the following information:

1. A detailed narrative description of the systems architecture, inputs, evacuation signaling, auxiliary functions, annunciation, sequence of operation, expansion capability, application considerations and limitations.
2. A detailed description of routine maintenance required or recommended, or as would be provided under a maintenance contract, including a testing schedule and detailed maintenance instructions for each type of device installed.
3. Detailed troubleshooting instructions for each possible trouble condition.
4. An equipment list/schedule detailing all equipment and quantities installed. The manufacturer’s product model/identification number shall be shown next to each piece of equipment on the list.

5. Updated manufacturer’s data sheets and installation manuals/instructions for all equipment installed.

6. A detailed description of the operation of the systems, including operator responses. Copies of the approved sequence of operation shall be placed in, or adjacent to the control panel.

I. A copy of all software documentation required by this section shall be maintained on-site by the Contractor, in a binder, arranged in chronological order. This binder shall be provided to the Owner’s Representative at the completion of the project.

J. Contractor to leave a CD copy of the fire alarm restore with instruction guide in cabinet ‘A’ located near the power wall.

1.8 QUALITY ASSURANCE

A. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.

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. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no less than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no less than 1 unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no less than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no less than 1 unit of each type.
5. Keys and Tools: One extra set for access to lock and tamperproof components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Fire Lite Alarms; a Honeywell company.
   2. NOTIFIER; a Honeywell company.
   3. SimplexGrinnell LP; a Tyco International company.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:
   2. Heat detectors.
   3. Smoke detectors.
   4. Duct smoke detectors.
   5. Verified automatic alarm operation of smoke detectors.
   6. Automatic sprinkler system water flow.
   7. Heat detectors in elevator shaft and pit.
   8. Fire-extinguishing system operation.
   9. Fire standpipe system.

B. Fire-alarm signal shall initiate the following actions:
   1. Continuously operate alarm notification appliances.
   2. Identify alarm at fire-alarm control unit and remote annunciators.
   3. Transmit an alarm signal to the remote alarm receiving station.
   4. Unlock electric door locks and exterior gates 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. Activate stairwell and elevator-shaft pressurization systems.
   9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
  10. Recall elevators to primary or alternate recall floors.
  11. Activate emergency shutoffs for gas and fuel supplies.
  12. Record events in the system memory.
C. Supervisory signal initiation shall be by one or more of the following devices and actions:
   1. Valve supervisory/tamper switch.
   2. Low-air-pressure switch of a dry-pipe sprinkler system.
   3. Elevator shunt-trip supervision.

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 primary power at fire-alarm control unit.
   4. Ground or a single break in fire-alarm control unit internal circuits.
   5. Abnormal ac voltage at fire-alarm control unit.
   7. Failure of battery charging.
   8. Abnormal position of any switch at fire-alarm control unit or annunciator.
   9. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.

E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Record the event on system printer.

2.3 FIRE-ALARM CONTROL UNIT

A. General Requirements for Fire-Alarm Control Unit:
   1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
      a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
      b. Include a real-time clock for time annotation of events on the event recorder and printer.
   2. Addressable initiation devices that communicate device identity and status.
      a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
      b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
   3. Addressable control circuits for operation of mechanical equipment.

B. 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, 3 lines 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.

C. Circuits:

1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
   a. Initiating Device Circuits: Style D.
   b. Notification Appliance Circuits: Style Z.
   d. Install no more than 50 addressable devices on each signaling line circuit.


D. Elevator Recall:

1. Smoke detectors at the following locations shall initiate automatic elevator recall.
   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 lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.

3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
   a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.

E. 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.

F. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

G. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

H. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire-alarm control unit.

1. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
a. Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
b. Programmable tone and message sequence selection.
c. Standard digitally recorded messages for "Evacuation" and "All Clear."
d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.

3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

I. 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 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.

J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

2.4 MANUAL FIRE-ALARM BOXES

A. 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. Single-action mechanism, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
   2. Station Reset: Key- or wrench-operated switch.
   3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
   4. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.5 SYSTEM SMOKE DETECTORS

A. 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 analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
   
   a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15°F or 20°F per minute.
   b. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at 135°F or 155°F.
   c. Provide multiple levels of detection sensitivity for each sensor.

8. Provide an automatic test feature to permit functional testing of the device from the main control panel. Indicate results of the test on the LCD display.

B. 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.).

C. Ionization Smoke Detector:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
   
   a. Primary status.
   b. Device type.
   c. Present average value.
   d. Present sensitivity selected.
   e. Sensor range (normal, dirty, etc.).

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. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
4. Each sensor shall have multiple levels of detection sensitivity.
5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.

E. Aspirating Smoke Detector
1. The Aspirating Smoke Detector (ASD) shall offer Very Early Warning Smoke Detection, Early Warning Smoke Detection and Standard Smoke Detection settings. The sensitivity range shall be from 0.00046%/ft – 4.0%/ft. Operating temperatures shall be from 32°F to 100°F. Sampled air temperatures shall range from –4° to 140°F. Operating humidity shall range from 10-95% non-condensing. The ASD shall have dual source (blue LED and infra-red laser) optical smoke detection for a wide range of fire detection with enhanced immunity to nuisance particulates. The ASD shall operate in air flows from 0-4000 ft/min.

2.6 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135°F or a rate of rise that exceeds 15°F per minute unless otherwise indicated.
   1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
   2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
   1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.

B. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

C. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

D. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

E. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch-high letters on the lens.
   1. Rated Light Output:
      a. 15/30/75/110 cd, selectable in the field.
2. Mounting: Wall or ceiling mounted. Locate on ceiling where possible and approved by local authority having jurisdiction.
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.

F. Voice/Tone Notification Appliances:
1. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
2. High-Range Units: Rated 2 to 15 W.
3. Low-Range Units: Rated 1 to 2 W.
5. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.8 MAGNETIC DOOR HOLDERS
A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
1. Electromagnet: Requires no more than 3 W to develop 25-lbf holding force.
2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
3. Rating: 24-V ac or dc.

2.9 REMOTE ANNUNCIATOR
A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
1. Mounting: Flush cabinet, NEMA 250, Type 1.

B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 ADDRESSABLE INTERFACE DEVICE
A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall.
2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one 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 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.
   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 or loss of power.
   5. Low battery.
   6. Abnormal test signal.
   7. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 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 manufacturer of device.
   2. Finish: Paint of color to match the protected device.

2.13 BACnet COMMUNICATION OUTPUT CARD

A. Provide an output communication card for BACnet protocol communications. The output shall be connected to the Data Center Energy Management System.
PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

A. Comply with NFPA 72 for installation of fire-alarm equipment.

B. Install wall-mounted equipment, with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
   1. Comply with requirements for seismic-restraint devices specified in Division 26 Section “Vibration and Seismic Controls for Electrical Systems.”

C. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.

D. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.

E. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

F. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.

G. Audible Alarm-Indicating Devices: Install not less than 6 inches below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.

H. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches below the ceiling.

I. Device Location-Indicating Lights: Locate in public space near the device they monitor.

J. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than 72 inches above the finished floor.

K. Annunciator: Install with top of panel not more than 72 inches above the finished floor.

L. All fire alarm cabling shall be routed in minimum 1” conduit. Provide larger conduit as required per NEC.

M. The Capillary Sampling Network
   1. Where false ceilings are installed, the sampling pipe shall be installed above the ceiling, and Capillary Sampling Points shall be installed on the ceiling and connected by means of a capillary tube.
   2. The minimum internal diameter of the Capillary tube shall be 5mm, the maximum length of the Capillary tube shall be 2m unless the manufacturer in consultation with the engineer have specified otherwise.
   3. The Capillary tube shall terminate at a Ceiling Sampling Point specifically designed and approved by the manufacturer. The performance characteristics of the Sampling Points shall be taken into account during the system design.
N. Air Sampling Pipe Network Calculations
   1. Air Sampling Pipe Network Calculations shall be provided by a sampling pipe aspiration modeling program such as ASPIRE (latest Version; ASPIRE for WindowsTM Version 2.9.2.). Pipework calculations shall be supplied with the proposed pipe layout design to indicate the following performance criteria:
      2. Transport Time
         a. The manufacturers recommended transport time (time taken for the smoke to enter the pipe and reach the detector) for the least favourable sampling point is 60 seconds or less.
         b. Local codes or end users standards may also apply. For example:
            1) NFPA72 US 120 Seconds
      3. The maximum transport time must never exceed the local codes.
   4. Balance Percent
      a. The sample point balance for the pipe shall not be less than 70% as indicated by ASPIRE. That is, the volume of air drawn from the last sampling point shall not be less than 70% of the average volume of air through the other holes.
   5. Share Percent
      a. The sample hole share for the pipe shall not be less that 70% as indicated by ASPIRE. That is, the sum volume of air drawn through the sampling holes must always be greater than 70% of the total volume of air entering the pipe (i.e. the End Vent must not exceed 30% of the total flow).

3.2 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 Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
   1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
   1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
   2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
   3. Smoke dampers in air ducts of designated air-conditioning duct systems.
   4. Alarm-initiating connection to elevator recall system and components.
   5. Alarm-initiating connection to activate emergency lighting control.
   6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
   7. Supervisory connections at valve supervisory switches.
   8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 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.

3.5 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Visual Inspection: Conduct visual inspection prior to testing.
   a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
   b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.


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.


D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

E. Fire-alarm system will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.
3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system for a minimum of eight (8) hours.

END OF SECTION 28 31 11
SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes: Provide all operations required in connection with the general clearing of the site, including the following:
1. Stripping of top soil
2. Clearing and grubbing of site areas at all new paving
3. Preservation of existing utilities
4. Demolition of existing above and below grade improvements as required by the Work of the Contract
5. Removal of all existing and generated trash and during clearing and grubbing
6. Location and protection of bench marks

B. Related Documents: The Contract Documents, as defined in Division 1 Section - Summary of Work, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

C. Related Sections include the following:
1. Division 2 Section “Earthwork.”

1.03 COORDINATION

A. Coordinate clearing work with the work of other related trades so as not to delay progress of any section of the work.

B. Notify and coordinate with any and all utility companies or agencies as required for capping, removal, by-passing or protections of existing utility lines.

1.04 GENERAL REQUIREMENTS
A. Comply with all applicable federal, state and local codes and ordinances and with the requirements of insurance carriers providing coverage for this work.

B. Procure and pay for all permits or certificates required for the work involved.

1.05 EXAMINATION OF SITE

A. Contractor shall visit and examine the site to ascertain the actual nature and scope of any demolition work. Later claims for additional compensation covering difficulties encountered in demolition work will not be recognized.

PART 2 - PRODUCTS

2.01 STOCK PILING

A. Store topsoil, stripped from site improvement areas, in areas designated or approved by Architect for distribution or removal later. Handle topsoil carefully to prevent contamination with undesirable materials. Topsoil so stored shall be reasonably free from debris.

B. Salvageable materials, if any, resulting from clearing work shall become the property of the Contractor, unless identified to be retained by the Owner.

PART 3 - EXECUTION

3.01 PREPARATION

A. Consult Owner prior to removal of existing trees and shrubs. Tag all plant material identified to remain.

3.02 PROTECTION

A. Before and during site clearing operations, Contractor shall ascertain where existing utilities are located. Any damage that may occur to existing services shall be promptly corrected by the Contractor at no additional cost to the Owner.

B. Prior to beginning stripping and clearing, coordinate with Architect on methods and markings of areas not to be disturbed.

C. Erect necessary barricades, and protective measures as required.

D. Protect trees, plant growth, and features designated to remain as final landscaping. Barricades shall be placed around the drip line of trees indicated to remain that are
within the construction area. Vehicle traffic shall not be allowed under any trees.

**STRIPPING OF TOPSOIL**

E. Scrape and remove all brush, weeds, grass, roots and other material from areas which are to be stripped of topsoil.

F. Strip to a depth of 6" from the areas within lines 5'-0" outside of foundation walls of buildings and from under all walk and paving areas.

G. Pile topsoil in designated locations, where it will not interfere with construction or utility operations, for use in planting areas. Remove excess and/or unacceptable topsoil from the site.

**3.03 CLEARING**

A. Clear the area within the limits to remove all subterranean or surface material, growth or other obstructions.

B. Remove all stones, stumps, roots, old concrete masses or other similar items larger than 3/4" diameter, to a minimum depth of 24" below natural grade in landscape bed areas and 6" below proposed grades in areas to be covered by building or paving.

C. Remove trees and stumps from area of improvements as shown on drawings. Do not remove other trees without approval from the Owner. Use methods of removal which will prevent damage to remaining plant materials and property.

D. Fill any holes left by removal of large stones or stumps per requirements of applicable articles of Division 31 Section – “Earthwork”. Compact backfill to the density of surrounding soils.

E. Following each day of grubbing activity, grade surface to remove open holes and ruts and allow unrestrained runoff of storm water. Ponding will not be permitted.

**3.04 DEMOLITION**

A. Remove all obstructions located within or outside the property lines that would interfere with installation of new work such as paving, walks, curbs, slabs, walls and other items. No high impact vibrations permitted. Execute all clearing work by methods which will prevent damage to other work or adjoining properties and which will prevent settlement or erosion to adjoining areas.

B. Unless otherwise noted to remain, clear the site of all existing pavements, concrete walks, concrete steps, fences, structures and the like to a depth of 24" below proposed grades.
C. Refer to Topographic Survey Drawing for location of existing items and structures which are affected by demolition and clearing/grubbing requirements.

3.05 DISPOSAL

A. Except as otherwise provided, all items cleared from the site, including all asphalt, concrete, building materials, rubbish, brush, stumps, debris, etc., resulting from the work of this section shall be removed and disposed of off-site.

END OF SECTION 31 10 00
SECTION 31 22 00
EARTHWORK

PART 1 - GENERAL

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

1.02 SUMMARY
A. Section Includes:
   1. Earthwork materials
   2. Excavating and backfill
   3. Preparing subgrade
   4. Soil stabilization
   5. Testing requirements
B. Related Documents: The Contract Documents, as defined in Division 1 Section - Summary of Work, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

1.03 SCOPE
A. Provide required earthwork relating to building structures and site improvements including excavation, fill, backfill and grading as shown on drawings and as herein specified.

1.04 SOIL REPORT
A. A copy of the soil report and test boring results is available from the Owner. This report is for information only and is not guaranteed for accuracy of existing conditions by Owner or Architect. Should this section conflict with requirements stated in the soils report, the soils report shall be governing. Notify the Structural Engineer as to those conflicts.

1.05 SAMPLES
A. Division 1 Section - Submittal Procedures: Procedures for submittals.
B. Submit samples of materials requiring laboratory testing in sufficient quantity necessary to adequately investigate soil.

1.06 JOB CONDITIONS

A. Maintain all existing and newly established bench marks. Report discrepancies found to the Architect, who reserves the right to make minor adjustments necessary to accomplish the intent of the Contract Documents, at no additional cost to the Owner. Contractor solely responsible for all elevations, dimensions, and verifications of conditions.

1.07 PROTECTION

A. Provide for surface drainage during the period of construction in a manner to avoid creating a nuisance to adjacent areas and to prevent water runoff into excavation. Provide pumping as required to keep excavated areas free of water during construction. Ponding of water during construction shall be prevented at all times.

B. Provide adequate sheeting, shoring and bracing for excavations to prevent caving and to protect personnel.

C. Protect all building walls, curbs, and slabs against discoloration or damage from work under this Section.

D. Protection of existing landscape features indicated to remain as a portion of final landscaping.

E. Protect above and below grade utilities to remain.

1.08 OBSTRUCTIONS

A. Should utilities be encountered which interfere with the work, it is the Contractor's responsibility to notify the Owner and Architect. The Owner shall direct the Contractor to remove, relocate or cap off same.

PART 2 - PRODUCTS

2.01 STOCK PILING

A. Fill material required to be hauled in may be stockpiled at site until used, provided it is properly handled to prevent contamination with undesirable materials. Stock pile topsoil separate from excavated subsoil.

2.02 SURPLUS MATERIALS
A. Remove excavated materials not suitable for use in fills and backfills on this project from site. Materials containing rubbish, debris or rocks shall be removed.

2.03 MATERIALS

A. Fill: (at pavement) on site, inorganic soil free from vegetable matter, debris, and other deleterious matter capable of being compacted to 95% maximum density at optimum moisture content; ASTM D-698, or select fill.

B. Select Fill: (within building lines and beneath paving areas) Homogenous and non-expansive, having a plasticity index between 5 and 20. Select fill shall contain no rock greater than 2” in maximum dimension. Submit lab analysis for approval, complete with lab analysis of fill.

C. Topsoil: Clean, natural topsoil free of vegetation, debris, and other deleterious matter. Upper 6" of topsoil stripped from site may be used.

D. Sand Cushion Under Slabs on Grade: Pit run sand graded in accord with ASTM C136, free of organic matter, clays or other binder materials. Submit samples for approval.

E. Vapor Barrier: Division 07 Section.

F. Lime: Hydrated lime conforming to applicable sections of ASTM C-207, Type N. Lime quantity tickets supplied to Owner’s testing lab upon delivery of each load.

G. Filter Fabric: Prefabricated drainage composite geotextile shall be Mirafi 140 Fabric at under-building drainage, or approved equal by JDR or Monsanto.

PART 3 - EXECUTION

3.01 EXCAVATION

A. Strip objectionable materials from areas to be graded before grading operation begins. Excavate subsoil required for building foundation construction operations and other work. Excavations and rough grading shall be made to lines and grades shown and "feathered" into adjoining grades to insure a smooth transition. Maintain excavations so they drain and are kept free of excess water. Provide pumping as required. Fill over-excavated areas under structure-bearing surfaces in accord with directions of Owner.

B. Any materials resulting from operations that are unsuitable for use or disposal at the site shall become the property of the Contractor and be removed from the site.
C. Trenching for underground piping, electrical conduits, etc., shall be done by the trade installing the pipes, conduits, etc. Backfilling of trenches shall conform to the requirements for compacted select fill.

D. Abandoned Utility Lines and Sewers: Plug in accordance with utility company and/or local requirements any abandoned lines or pipes encountered during excavation using concrete plugs at least 6” thick and at a minimum distance of 3’ outside improved areas.

E. Finish excavations within a tolerance of .05 foot above or 0.1 foot below required grades.

3.02 SUBGRADE PREPARATION AND FILLING

A. Lay out work to insure that all finish grades of all paving have the proper slope to insure proper drainage.

B. Establish new grades as necessary and verify all measurements and grades. Set all stakes, etc., to insure an engineering degree of accuracy.

C. Establish all grades and curbs of adjacent streets.

D. Scarify exposed subgrade to a depth of 6″ and re-compact to a minimum of 98% of standard proctor density (ASTM D-698) at its optimum moisture content to 4% above its optimum moisture content.

E. Provide select fill material. Select fill material shall be placed in loose lifts of 6″ to 8″ thick and uniformly compacted to a minimum of 95% of standard proctor density (ASTM D-698) at minus 1% to plus 2% of its optimum moisture content.

F. Additional fill may be clean, on-site clays free of debris, vegetation, and organic material. Clay fill shall be placed in 8″ maximum loose lifts at +5% to -3% of optimum moisture and compacted to 95% of the standard proctor dry density (ASTM D-698). Moisture content shall be maintained until pavement or additional fill is placed.

G. The cross-section of the finished subgrade shall be free from ridges or valleys and be within 0.05 of a foot above or below the theoretical section at any point on the cross-section.

H. Finished subgrade that does not conform to the above requirement shall be bladed and thoroughly re-compacted to conform to the requirements.

I. Clean surface or subgrade of all loose materials by brooming or other approved methods.

3.03 SOIL STABILIZATION
A. Subgrade of all paving shall be lime stabilized.

B. Insure that surfaces have been brought to approximate rough grades.

C. Loosen and pulverize soil to a compacted depth of 6’ beneath designated paving areas including a distance of 2 feet outside perimeter of paving.

D. Mix soil and lime thoroughly by approved road mixer or other equipment until a homogeneous, friable mixture of soil and lime is obtained; free from all clods or lumps.

E. Begin compaction of the mixture immediately after final mixing. Aerate or sprinkler material as necessary to provide optimum moisture. Begin compaction at the bottom and continue until entire depth of the mixture is uniformly compacted.

F. A minimum of 7% hydrated lime (THD Item 264) (COG Item 4.6) should be used. Lime should be thoroughly mixed and blended with the top 6” of the subgrade (THD Item 260) and the mixture compacted to a minimum of 95% of ASTM D-698 at its optimum moisture content to 4% above its optimum moisture content.

G. Rework as necessary to obtain the specified density if any portion fails to meet the density specified.

H. Shape surface after mixture has been compacted to the required lines, grades and cross-sections and thoroughly roll with pneumatic or other suitable rollers sufficient light to prevent hair cracking.

I. Prepare only sufficient amount of subgrade in advance of placing paving, walks, curbs, etc., to enable the work to proceed smoothly and effectively.

3.04 BACKFILLING

A. Do not backfill against grade beams until after form work has been removed and concrete has set up. Backfill against grade beams so as to provide positive drainage away from the structure.

B. Finished subgrade surfaces generally not more than 0.5 inches above or below established grades. Tolerance for areas within 10 feet of building and all areas to be paved not more than .25 inches above or below established grades. Provide roundings at top and bottom of banks and at other breaks in grade. Unless otherwise noted, subgrade evenly sloped to provide drainage away from building walls, slope 1/4 inch per foot.

C. Compact backfill to 95% of maximum density at 2% below and 3% above optimum moisture content as determined by standard proctor test (ASTM D-698).

D. Backfill over filter fabric in tot lots with washed river gravel of 1/4 to 3/4” size and overlay with additional layer of filter fabric prior to installation of wood mulch.
3.05 VAPOR BARRIER

A. Place under all floor slabs on grade. Lap all joints 6” minimum and seal with compound recommended by manufacturer; seal around all openings through vapor barrier.

3.06 GRADING

A. After site has been cleared of construction debris, grade the site to the contours and spot elevation.

B. Ponding of water on the site will not be permitted. Finished grades shall not be more than 0.10 foot above or below established grade elevations.

3.07 PROTECTION, CLEAN-UP AND EXCESS MATERIAL

A. Protect grades from construction and weather damage, washing, erosion and rutting, and repair such damage that occurs.

B. Correct any settlement below established grades to prevent ponding of water.

C. Remove excess stock pile materials, debris, waste and other materials from site and leave work in clean, finished condition for final acceptance. Contractor is responsible for disposal of debris and excess materials.

3.08 FIELD QUALITY CONTROL

A. The Owner will employ and pay for services of an independent testing laboratory to perform inspection and testing services specified in this section.

B. Excavation: Observe the excavation process on a periodic basis, noting the exposed faces of the excavation. Immediately report any observed unsafe conditions.

C. Filling and Backfilling:
   1. The Contractor shall make available to the laboratory, adequate samples of each fill and backfill material from the proposed sources of supply not less than 10 days prior to the start of the work.
   2. The Laboratory shall analyze the samples as required to provide a soil description and to determine compliance with the quality requirements.
      a. Test for liquid limit in accordance with ASTM D423.
      b. Test for plastic limit of soils and plasticity index of soils in accordance with ASTM D424.
      c. Test for moisture density relations of soil in accordance with ASTM D698.
   3. Furnish a report for each individual test and state whether sample conforms to the specified requirements or reasons for nonconformance.
4. Inspect and approve subgrade prior to placement of fill material.
5. Make in-place compaction tests for moisture content, moisture-density relationship, and density of fill materials.
6. Perform not less than two compaction tests for each 3,000 SF of surface for each layer of fill under the building and not less than two compaction tests for each 5,000 SF of surface for each layer of fill or undisturbed earth on areas of site to be covered by paving walks or traffic approaches.

D. Footing Excavations: Inspect footing excavations to determine that the proper bearing stratum is obtained and that excavations are properly clean and dry before concrete is placed.

END OF SECTION 31 22 00
SECTION 31 23 00
EXCAVATION AND FILL

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Excavating and backfilling for structures, utilities, and pavement.
   2. Pipe bedding.
   3. Compacting fill materials.
   4. Borings and casings under roads.

B. Related Documents: The Contract Documents, as defined in Division 1 Section -
   Summary of Work, apply to the Work of this Section. Additional requirements and
   information necessary to complete the Work of this Section may be found in other
   Documents.

1.02 DEFINITIONS

A. Building Area Subgrade Pad: Portion of site directly beneath and within a line 10
   feet beyond building and appurtenances including limits of any future building
   expansion areas indicated on Drawings.

1.03 SUBMITTALS

A. Division 1 Section - Submittal Procedures: Procedures for submittals.
   1. Assurance/Control Submittals:
      a. Material Source: Submit name of imported materials suppliers. Provide
         materials from same source throughout the work. Change of source
         requires Architect approval.
      b. Test Reports: Submit the following reports directly to Architect from
         Testing Laboratory, with copy to Contractor:
         1) Test reports on borrow material.
         2) Verification of each footing subgrade.
         3) Field density test reports.
         4) Optimum moisture-maximum density curve for each type of soil
            encountered.
         5) Report of actual unconfined compressive strength and bearing
            tests/results for each strata tested. Give "three-dimensional"
            description of each test location.
B. Division 1 Section - Closeout Submittals: Procedures for closeout submittals.
   1. Project Record Documents: Accurately record the following.
      a. Spot elevations for building area subgrade pad.
      b. Location of existing utilities remaining, re-routed utilities, new utilities by horizontal dimensions, elevations or inverts, and slope gradients.

1.04 PROJECT CONDITIONS OR SITE CONDITIONS

A. Existing Conditions: Requirements specified in Division 2 Section.

B. Existing Utilities: Requirements specified in Division 2 Section.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Stockpiled on-site fill and backfill material specified in Division 31 Section, tested by Testing Laboratory and approved by Architect.

B. Imported off-site fill and backfill material specified in Division 31 Section, tested by Testing Laboratory and approved by Architect.

C. Pipe Bedding Material: Processed sand and gravel free from clay lumps, organic, or other deleterious material complying with the following gradation requirements:
   a. SIEVE SIZE     PERCENT PASSING
   b. 1 Inch        100
   c. 3/4 Inch      90 to 100
   d. 3/8 Inch      20 to 55
   e. No. 4         0 to 10
   f. No. 8         0 to 5

D. Steel Casing Pipe: AWWA C 200, minimum grade B; size and wall thickness as indicated on Drawings.

E. Stabilization Fabrics and Geogrids:
   1. Mirafi 500X or 600X.
   3. Reemay Typar 3401 and 3601.
   4. Trevira S1114 and S1120.
   5. Tensar 1100 and 1200.

F. Filter/Drainage Fabrics:
   1. Mirafi 140 N.
   2. Amoco Style #4546.
   3. Reemay Typar 3341.
2.02 EXCAVATION

A. Excavation for filling and grading specified in Division 31 Section.

B. Rock excavation specified in Division 31 Section.

C. Excavation for Structures:
   1. Excavate subbase for building foundations, slabs-on-grade and site structures to width and depth indicated on Drawings.
      a. Cut excavation banks vertically.
      b. Remove rocks, loose soil, and debris from bottom of excavation.
      c. Overexcavate wet or unsuitable soil from bottom of excavation.
      d. Provide stable base for concrete reinforcing installation and concrete placement.
      e. Hand trim to indicated lines and grades just prior to concrete reinforcing installation.
   2. Provide protection for workers within trench areas in accordance with local, state, and national Occupational Safety and Health requirements and regulations.
      a. Trenches minimum 4 feet in depth.
   3. During excavation, stockpile materials suitable for backfilling away from excavation to prevent overloading, slides, or cave-ins.
   4. Remove material encountered in excavating operations that is unsuitable for backfilling, subgrade or foundation purposes as determined by Testing Laboratory and Architect. Dispose of materials off-site in an approved manner in accordance with requirements of authorities having jurisdiction.
   5. Prevent surface water from flowing into excavations by temporary grading or other approved methods.
      a. Do not allow water to accumulate in excavations.
      b. Remove accumulated water in excavations.
      c. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components required to remove water from excavations.

D. Excavation for Utilities:
   1. Excavate trench width and depth required for laying pipe, conduit, or cable. Cut trench banks vertical. Remove stones from bottom of trench as required to avoid point-bearing. Over excavate wet or unstable soil, if encountered, from trench bottom as required to provide suitable base for continuous and uniform bedding.
   2. During excavation, stockpile materials suitable for backfilling away from trench bank to prevent overloading, slides, or cave-ins.
   3. Remove material encountered in trenching operations that is unsuitable for backfilling, subgrade or foundation purposes as determined by Testing Laboratory and Architect.
Laboratory and Architect. Dispose of materials off-site in an approved manner in accordance with requirements of authorities having jurisdiction.

4. Prevent surface water from flowing into trenches or other excavations by temporary grading or other approved methods.
   a. Do not allow water to accumulate in excavations.
   b. Remove accumulated water in excavations.
   c. Provide and maintain pumps, well points, sumps, suction and discharge lines and other dewatering system components required to remove water from excavations.

5. Open cut excavation using trenching machine or backhoe. Do not use dirt clods for backfill created by use of machines other than ladder or wheel-type trenching machines.

6. Grade trench bottom to provide uniform bearing and support for each section of pipe on bedding material along entire trench length, except where necessary to excavate for bell holes, proper sealing of pipe joints, or other required connections. Dig bell holes and depressions for joints after trench bottom has been graded. Do not excavate trench deeper, longer, or wider than required to make proper joint connection.

7. Excavate trench width below the top of pipe minimum 300 mm wide and maximum 460 mm wider than outside surface of pipe or conduit installed to elevations and grades indicated on Drawings. Excavate trench width for other pipe, conduit, or cable to least practical width allowing for proper compaction of trench backfill.

8. Excavate trench depth measured from finished grade or paved surface to the following requirements or applicable codes and ordinances:
   a. Water Mains: 30 inches to top of pipe barrel or 6 inches below frost line established by local building official, whichever is deeper.
   b. Sanitary Sewer: Elevations, and grades indicated on Drawings.
   c. Storm Sewer: Depths, elevations, and grades indicated on Drawings.
   d. Electrical Conduits: 24 inches minimum to top of conduit or as required by NFPA 70, or local utility company requirements, whichever is deeper.
   e. TV Conduits: 18 inches minimum to top of conduit or as required by local utility company, whichever is deeper.
   f. Telephone Conduits: 18 inches minimum to top of conduit, or as required by local utility company, whichever is deeper.
   g. Gas Mains and Service: 30 inches minimum to top of pipe, or as required by local utility company, whichever is deeper.

9. Provide shoring, sheeting, and bracing, as required, in trenches and other excavations where protection of construction personnel is required. Sheet ing may be removed after sufficient backfilling to protect against damaging or injurious caving.

E. Excavation for Pavement:
   1. Excavate roadway and pavement areas to line and grade indicated on Drawings.
   2. Stockpile excavated material suitable for backfilling on-site.
3. Remove excavated materials not required or not suitable for backfill from site.
4. Overexcavate areas of pavement subgrade found to contain unsuitable material. Prepare, fill with suitable material, and compact as specified. Stabilize areas as specified in Division 31 Section.

2.03 PIPE BEDDING

A. Excavate trenches, for pipe or conduit installed to elevations indicated on Drawings, 4 inches below bottom of pipe and to width as specified. Place 4 inches of bedding material, compact in bottom of trench, and shape to conform to lower portion of pipe barrel. After pipe installation, backfill and compact to top of trench.

B. Place geotextile fabric as indicated on Drawings.

2.04 BACKFILLING AND SUBGRADE PREPARATION

A. Backfilling:
1. Verify that imported off-site fill and stockpiled on-site fill is tested and approved.
2. Verify that foundation perimeter drainage installation is inspected and approved.
3. Verify that foundation or below grade structure walls are braced to support surcharge forces imposed by backfilling operations.
4. Verify that backfill areas are free of debris, snow, ice, or water, and that ground surfaces are not frozen.

B. Prepare building area subgrade pad in accordance with foundation subsurface preparation information indicated on Drawings and specified herein. Do not use rock larger than 6 inches for building subgrade fill.

C. Areas Exposed by Excavation or Stripping:
1. Scarify areas exposed by excavation or stripping on which building subgrade preparations are to be performed to minimum 8 inch depth.
2. Compact to minimum 92 percent optimum density in accordance with ASTM D698 (Standard Proctor) at minimum moisture content 2 percent below and maximum 2 percent above optimum moisture content.
3. Proofroll to detect any areas of insufficient compaction by making minimum of 2 complete passes with fully-loaded tandem-axle dump truck, or Architect approved equivalent, in each of two perpendicular directions under supervision and direction of Architect.
4. Excavate and recompact areas failing to meet specified requirements.

D. Fill Material Placement:
1. Place in 8 inch maximum lifts compacted minimum 95 percent optimum density in accordance with ASTM D698 (Standard Proctor) at minimum moisture
content of 2 percent below and maximum moisture content 2 percent above optimum moisture content.

2. Maximum allowable values for plasticity index (PI) and liquid limit (LL) of suitable fill materials to be used as fill in the specified areas, unless indicated otherwise on Drawings:

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>PI</th>
<th>LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building area, below upper 4 feet</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Building area, upper 4 feet</td>
<td>30</td>
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</tr>
<tr>
<td>Building area, below upper 4 feet of proposed subgrade elevation</td>
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<tr>
<td>Building area, upper 4 feet of proposed subgrade elevation</td>
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<tr>
<td>Paving area, below upper 4 feet of proposed subgrade elevation</td>
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<tr>
<td>Paving area, upper 4 feet of proposed subgrade elevation</td>
<td>30</td>
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</tbody>
</table>

E. Provide material imported from off-site with CBR (California Bearing Ratio) or LBR (Limerock Bearing Ratio) value equal to or above pavement design subgrade CBR or LBR value indicated on Drawings.

2.05 MAINTENANCE OF SUBGRADE

A. Verify finished subgrades for elevations indicated on Drawings and specified conditions for construction above subgrade.

B. Protect subgrade from excessive wheel loading during construction, including concrete trucks and dump trucks.

C. Remove areas of finished subgrade found to have insufficient compaction density. Replace in a manner that will comply with compaction requirements as directed by Architect. Provide hard, uniform, smooth, stable surface, true to grade and cross-section after completion of compaction.

2.06 PROTECTION

A. Protect building subgrade pad and building related earthwork from damage by construction operations and erosion.

B. Prohibit vehicles from entering building subgrade pad area. Vehicles not permitted.

C. Scarify surface, reshape, and compact areas damaged by construction operations or weather erosion.

END OF SECTION 31 23 00
SECTION 31 25 53
SOIL EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes: This section specifies soil erosion and sediment control work during construction, as shown. The work includes, but is not limited to, furnishing and installing straw bales or silt fence to form dikes or to form ditch, basin, and drop inlet erosion check; constructing earth perimeter dikes and overflow outlets; constructing crushed stone sediment traps and earth embankments; constructing sediment basins; constructing silt fences; placing riprap; and, furnishing and installing seed or sod for erosion control.

B. Related Documents: The Contract Documents, as defined in Division 1 Section - Summary of Work, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

C. Related Sections include the following:
   1. Division 31 Section: Earthwork
   2. Division 31 Section: Excavation and Fill

D. The work performed under this section shall comply with the Storm Water Pollution Plan for this Project and with the requirements and intent of the NPDES Storm Water Discharge Permit program.

1.03 QUALITY ASSURANCE

A. The following Codes, Regulations, Reference Standards, and Specifications apply to work included in this section:

B. Codes and regulation of the jurisdictional authorities, including the NPDES general permit for storm water discharges associates with the construction activity.

C. “REFERENCE CODES AND STANDARDS”: 
1. AASHTO: M-43 M182.
4. Sampling and testing concrete masonry units shall be in accordance with ASTM C140.

1.04 SUBMITTALS

A. Submit the following for approval in accordance with Division 1 Section: “Submittal Procedures”, and with the additional requirements as specified for each:

B. Certification of each item listed in this section with the appropriate samples, manufacturer’s specifications and catalogue information.

C. Storm Water Pollution Prevention - Contractor Certification:
   1. Prior to commencement of construction activities, the Contractor shall submit to the City where the project is located, or to the Authorities having Jurisdiction, a signed copy of the following certification statement, to be filed with the Storm Water Pollution Prevention Plan (SWPPP):
   2. “I certify, under penalty of the law, that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site, identified as part of this certification”.

PART 2 - PRODUCTS

2.01 STRAW BALES

   A. Provide straw or hay bales approximately 36 inches long by 24 inches wide by 18 inches high; minimum 60 pounds, maximum 120 pounds each; bound with galvanized wire or nylon rope tied across stem lengths.

2.02 STAKES

   A. Provide nominal 2 inches by 2 inches wooden stakes with sharpened ends or minimum 1/2-inch diameter steel picket rebar. Stakes: approximately 3 feet in length.

2.03 CRUSHED STONE

   A. AASHTO M43: Size No. 2 or 24.
2.04 SEED AND SOD
A. As specified in Division 32 Sections: “Landscape Seeding” and “Turf and Grasses”.

2.05 APPROVED FILL
A. Fill material for embankments, dikes, and erosion checks: as specified in Division 31 Sections: “Earthwork” and “Excavation and Fill”.

2.06 TOPSOIL
A. As specified in Division 32 Sections: “Landscape Seeding” and “Turf and Grasses”.

2.07 JUTE MATTING (MESH)
A. Provide jute matting of a uniform, plain weave with wrap, and weft yarns of approximately the same size. The physical requirements shall be:
   1. Width: 45 inches to 48 inches, plus or minus one inch.
   2. 78 warp ends per width.
   3. 41 weft ends per yard.
   4. Weight - 1.80 lbs. (average) per running yard.

2.08 SILT FENCE MATERIALS
A. Silt Fence Fabric:
   1. One of the following:
   3. Edges treated to prevent unraveling.
   4. Furnished with 0-rings or clips to facilitate attachment to woven wire fabric.

B. Woven Wire Fabric: ASTM A116, Class 3 Coating; or ASTM A584, Class II Coating.

C. Posts:
   1. Steel, T-section, minimum 4 feet 6 inches long, minimum of 1.3 lbs. per foot without anchor plate.
   2. Anchor plate attached before coating.
   3. Fabricated with lugs or other approved means to prevent vertical movement of the woven wire fabric.

D. Coatings for Posts:
   1. Factory Painted:
a. Prime coat: As specified in Division 09 Section: “Painting” for steel.
b. Final Coat: Aluminum paint.

E. Tie Wire: Galvanized in accordance with ASTM A112.

PART 3 - EXECUTION

3.01 CONDITION OF SUBSTRATE

A. Examine the areas and conditions under which soil erosion and sediment control work is to be completed.

B. Stabilize fill and grade of areas to receive soil erosion and sediment control. Maintain positive drainage to sediment and erosion control devices during and after grading operations.

3.02 STRAW BALE DIKE INSTALLATION

A. Place bales in a row with ends abutting one another. Embed each bale in soil a minimum of 4 inches. Place anchor bales with two stakes driven through bales and sunk a minimum 1-1/2 feet into stabilized earth. Angle the initial stake toward previously laid bale to force bales together. Drive stakes flush with top bales. Remove bale dikes when no longer useful for controlling drainage and water flow.

3.03 STRAW BALE EROSION CHECK INSTALLATION

A. Ditch Erosion Checks:
   1. Where ditches are cut into existing ground and side slopes, place ditch erosion checks, consisting of bales, across the ditch slope invert. Install at least two bales across the ditch invert. Install additional bales on the ditch slopes, as shown, or when directed. Stake two overlapping bales staked up each ditch side slope. Set overlaps tight to eliminate openings in the ditch erosion check.

B. Basin and Drop Inlet Erosion Check:
   1. Where basins and drop inlets are located in the ditch line and off the paved areas, install baled straw erosion checks as shown. Protect entrance structures with straw bales staked upstream around drainage structure to ensure elimination add soil and silt from entering the underground drainage system. Stake one bale perpendicular to the flowline directly upstream from the inlet. Set two additional bales parallel to the flowline at each end of the bale. Stake all bales tightly against each other to eliminate any possible openings. Where shown, or when directed, embed the bales 4 inches into the ground around structures.
C. When the buildup of soil and silt behind the baled soil erosion checks reaches a height of 12 inches or when the checks are no longer functioning efficiently, remove the accumulated material. Bales shall be replaced every three months to maintain effectiveness of the sediment control measure.

D. Remove baled straw used for erosion checks when approved, or when the project is completed.

E. In no cases shall bales be left in ditches and around drainage structures after all construction is finished.

F. Curb Inlet Erosion Checks:
   1. Protect entrance structure with straw bales paralleled with the gutter flowline to ensure elimination of soil and silt from entering the underground drainage system.

G. Shoulder Drain Erosion Check:
   1. Where ballast drains are installed before placement of ballast, the following shall be installed. Install straw bale erosion checks as shown. Protect entrance structure with straw bales staked around ballast drain to ensure elimination of soil and silt from entering the underground drainage system. All bales shall be tightly staked against each other to eliminate any possible openings. All straw bales around ballast drains shall be removed just prior to installation of ballast.

3.04 PERIMETER EARTH DIKE AND OVERFLOW OUTLET INSTALLATIONS

A. Construct dikes with suitable backfill material, machine compacted, with positive drainage to outlets. Divert runoff from protected and stabilized upland areas to outlets with stabilized soil or grade stabilization behind outlets. Divert runoff from disturbed and exposed upland area to sediment traps or basins. Level to grad both earth dikes and overflow outlets once the sod area has stabilized. Remove stones, roots, and other extraneous materials larger than 2 inches any dimension.

B. Construct overflow outlets in perimeter earth dikes of compacted crushed stone embedded a minimum of 4 inches into the earth dikes. Construct the crest of outlets approximately 6 to 8 inches below height of adjoining earth dike.

C. Remove overflow outlets from the site once the soil area has properly stabilized.

3.05 SEDIMENT TRAP AND EMBANKMENT INSTALLATIONS

A. Construct sediment traps as shown on the drawings using crushed stone at outlets, existing backfill and soil materials for embankments, with stabilizing cores consisting of straw bales, concrete blocks, or timber.
   1. Clear, grub, and grade areas under embankments and trap outlets prior to placing embankments. Clear pool areas.
2. Where used as core material for outlets and embankments, anchor straw bales in place with two stakes per bale. Drive stakes through bales and into stabilized soil a minimum of 1-1/2 feet.
3. Place and compact embankment material.
4. Place and compact crushed stone solidly over core at outlets. Crest of outlets shall be approximately 10 to 12 inches below height of adjoining embankment.
5. Unless otherwise shown, construct cut and fill slopes at 3:1, or flatter.
6. Place jute matting (mesh) over embankments as shown. Securely anchor matting with stakes or stays.
7. When sediment has accumulated to 1/2 the design depth of the trap or 1 foot, whichever is less, remove sediment and deposit such material in a previously approved area which is free of erosion.
8. Remove sediment traps and embankments once the soil area has been properly stabilized as determined by the Architect.

B. Construct sediment basins in compliance with the “Standard and Specifications for Sediment Basin” as published by the U.S. Department of Agriculture Soil Conservation service in its volume “Standards and Specification for Soil Erosion and Sediment Control in Developing Area”.

3.06 SODDING
A. Perform sodding work when temperatures are 40 deg. F or higher. Do not place sod when ground surface is frozen or during extended drought.
B. Loosen subgrade of areas to be sodded and apply topsoil mixture over the area.
C. Lay sod within 20 hours from time of stripping.
D. Peg sod on slopes as required to prevent slippage. Use 1 inch by 1 inch by 6 inch wooden pegs with one end sharpened.
E. Provide fertilizer and soil amendments as required to maintain healthy sodded areas.
F. Sod areas to the limits indicated on drawings.
G. Stabilize channel flow areas disturbed by the Contractor’s operations with specified sod. Sod invert of ditches to 2 feet above invert.

3.07 SEEDING
A. Place and prepare topsoil as specified in Division 32 Sections: “Landscape Seeding” and “Turf and Grasses”.

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JQ Project # 3150040
B. Place seed and fertilize as specified in Division 32 Sections: “Landscape Seeding” and “Turf and Grasses”.

3.08 SILT FENCE

A. Install steel posts on a minimum of 8 foot centers. Minimum embedment of 1 foot 6 inches.

B. Minimum height of the silt fence to be 2 feet 6 inches with a 6 inch clearance between the top of the silt fence and the top of the posts.

C. Install the steel posts on a slight angle towards the anticipated runoff surface.

D. Trench in the toe of the silt fence so that the downslope faces of the trench is flat and perpendicular to the lie of flow.

E. Minimum trench depth: 6 inches.

F. Trench width: 3 to 4 inches.

G. Attach welded wire fabric to the posts.

H. Attach the silt fence fabric to the welded wire fabric and secure with a minimum of two wraps.

I. Backfill over the silt fence fabric.

J. When build up of soil, silt, or any other material behind the silt fence reaches a height of 6 inches or when the fence is no longer functioning efficiently, remove all accumulated material. The accumulated material shall be disposed of as set forth in Division 01 Section: “Construction Waste Management”.

3.09 CONTROL AND DISPOSAL OF EXCESS MATERIAL, TRASH, DEBRIS, AND EFFLUENT

A. Dispose of excess excavated material that is approved by the Architect as clean fill if an onsite soil disposal areas has been approved. If no such site is approved, dispose of material in accordance with the provisions of Division 01 Section: “Construction Waste Management”. Small amounts of material generated by excavation for fencing, etc. may be exempted from this provision. In all cases the provisions of Division 01 Section: “Construction Waste Management” apply to the onsite disposal of excavated material.

B. Pick-up trash and place in containers. Empty containers on a regular schedule. Conduct handling and disposal to prevent contamination of the site and others areas. Do not dispose of in wetlands and do not burn on the Right-of Way (ROW). On completion, leave the disposal areas clean.
C. Dispose of rubbish and debris as follows:
   1. Transport all waste off the site and dispose of in a manner that complies with State, and local requirements. Secure a permit or license prior to transporting any material off the site. Submit copies of approval documents from appropriate Authorities to the Architect prior to use of the disposal sites. Do not burn waste materials on site. Effluent:
   2. The Contractor shall take all necessary measures to assure compliance with the requirements of the NPDES Storm Water Discharge Permit obtained for this Project, and with the Storm Water Pollution Prevention Plan developed for this Project.

### 3.10 PROTECTION AND MAINTENANCE

A. Protect erosion and sediment control devices from damage. Repair and replace dikes, erosion checks, sediment traps, silt fences, overflow outlets, and other measures when damaged by construction, natural, and other physical causes. All soil erosion and sediment control device shall be repaired or replaced at the expense of the contractor and shall function as originally intended.

B. Periodically (at least once every 7 days and after each rainfall event) inspect and maintain erosion and sediment control structures, until final stabilization is achieved.

C. Maintain sod by watering, fertilizing, weeding, mowing, and trimming. Replace sod which has been eroded, damaged by construction activities, deteriorated, or diseased.

D. All stockpiled soil shall be surrounded by a straw bale dike or silt fence to properly control sediment runoff. All material and labor required to install and maintain the erosion control at soil stockpiles shall be included in the Contract.

E. Inspection services provided by the project City’s representative do not relieve the Contractor’s responsibility for inspection and maintenance of the erosion control measures, or his duty to comply with the Storm Water Pollution Prevention Plan and the conditions of the NPDES General Permit.

### 3.11 ACCEPTANCE

A. Soil erosion and sediment control devices will be acceptable, provided that they are in good condition and functioning as intended.

B. Sodded areas will be acceptable, provided that all requirements, including maintenance, have been complied with, and a healthy, well-rooted, even-colored, viable sod is established.

### 3.12 STAGING AREAS
A. At such time when the specific location of the staging areas are determined, silt fences, straw bale dikes, or equivalent sediment controls are required for all sideslope and downslope boundaries of the staging area or a detention basin providing storage for runoff from the staging area from a 10 year, 24-hour storm shall be provided. This erosion control plan shall be approved by the Architect and shall be in place prior to occupation of the staging areas. All relative material and labor to construct and maintain the staging area erosion control plan shall be subsidiary to the other items of work. Plan, schedule, and undertake work in a manner that will ensure protection and preservation of existing wetlands and water courses identified by the Corps of Engineers and the U.S. Fish and Wildlife Service.

3.13 VEGETATIVE PRACTICES

A. Temporary seeding, permanent seeding, mulching, or sod stabilization procedures, or their equivalent, must be initiated on all disturbed areas within 14 calendar days of last activity in that area. Temporary seeding, or sod and/or soil stabilization procedures will not be paid for directly, but will be considered subsidiary to the Contract. All permanent soil stabilization procedures shall be installed, measured, and paid for by the Contractor, and shall be in accordance with Division 32 Sections: “Landscape Seeding” and “Turf and Grasses”.

END OF SECTION 31 25 53
SECTION 32 13 13
CONCRETE PAVING

PART 1 - GENERAL

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

1.02 SUMMARY
A. Section Includes:
   1. Provide concrete paving including broom finished paving and walks, curbs and gutters. Restore paved areas opened or damaged in performance of the work required by the Contract Documents.

   B. Related Documents: The Contract Documents, as defined in Division 1 Section - Summary of Work, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

   C. Related Sections include the following:
      1. Division 1 Section “Laboratory Testing.”
      2. Division 3 Section “Concrete Formwork.”
      3. Division 3 Section “Cast-in-Place Concrete.”
      4. Division 7 Section “Joint Sealants.”
      5. Division 31 Section “Earthwork.”

1.03 SUBMITTALS
A. Division 1 Section - Submittal Procedures: Procedures for submittals.

   B. Concrete Design: Contractor shall be responsible for and shall pay for design of concrete mixes. An independent testing laboratory shall determine design mixes of each type concrete based on specified strengths and materials in accordance with ACI 318-89. Submit 4 copies of each design mix for approval.

1.04 COORDINATION
A. Notify responsible trades of schedules of concrete pours so as to allow adequate 
time for installation of their work.

1.05 STANDARDS

A. American Society for Testing Materials (ASTM).

B. American Concrete Institute ACI-617 "Standard Specifications for Concrete 
Pavement and Bases". ACI-396 "Manual of Standard Practice for Detailing 
Reinforced Concrete".

PART 2 - PRODUCTS

2.01 MATERIALS

A. Portland Cement: ASTM C-150-78a, Type I or III.

B. Fine Aggregate: Natural sand, ASTM C-33-78.

C. Coarse Aggregate: Hard, durable natural gravel or crushed rock meeting 
requirements of ASTM C-33-78. Maximum size and gradation in accordance with 
Size No. 67 or 467 in Table II of ASTM C-33.


E. Water: Potable.

F. Reinforcing Steel: ASTM A615, grade 60 or as noted on drawings.

G. Dowels and Sleeves: 3/4" plain round bars, with plastic sleeve at one end, 24 inches 
long, allowing one inch of movement. Refer to drawings.

H. Forms: Nominal 2" thickness dimension fir, or steel paving forms.


J. Dispersing Admixture: Cement-dispersing, water reducing compound complying 
with ASTM C-494 such as Pozzolith 100 series, as made by Master Builders.

K. Curing Compound at Standard Paving: ASTM C-309, No. 40W by A. C. Horn Co., 
Kure-N-Seal by Sonneborn or Clear Bond by Guardian Chemical.

L. Air Entraining: ASTM C-0260 by Master Builders or equal.

M. No fly ash will be permitted.
N. Color admixture: At locations indicated on drawings provide integrally colored concrete. Admixture shall be “Chromix” by L.M. Scofield Co., color as selected by Architect.

O. Curing Compound at integrally colored concrete: color matched curing compound compatible with integral coloring product. Curing compound shall be “Color Wax” by L.M. Scofield or approved equal, color as selected by Architect.

2.02 PROPORTIONING AND MIXING

A. Proportions and Design: Concrete shall produce a mixture of adequate workability, free from segregation, honeycombing and bleeding, and shall be of following types:

1. Schedule of Types of Concrete:

<table>
<thead>
<tr>
<th>Type</th>
<th>Min. All. Comp.</th>
<th>Max. Size of Aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>3500 psi</td>
<td>Gray P 5% 1-1/2&quot;</td>
</tr>
</tbody>
</table>

2. Locations of Types of Concrete: Broom finish all paving. Sidewalks shall be 4" thick and paving shall be 6" thick at parking and 7" thick where subject to truck traffic as noted on drawings.

3. Admixture: Add specified cement-dispersing agent, color admix (where specified) and air-entraining agent to concrete mixes.

B. Mixing: Ready mixed concrete in accordance with ASTM C-94-67.

C. Slump: Shall not exceed 5" or less than 3" per ASTM C-143.

D. Air Entrainment: Air content by volume as per ASTM C231 shall be 5% to 7% based on measurements made in concrete mixtures at point of discharge at job site.

PART 3 - EXECUTION

3.01 INSPECTION AND PREPARATION

A. Inspect subgrade and report any discrepancies to Architect before proceeding.

3.02 FORMWORK

A. Build forms to lines and grades detailed, of sufficient strength and rigidity so they will not deflect under pressure of wet concrete. Exercise extreme care in layout, bracing, and aligning forms. Formwork shall be straight, with no bulges in completed work greater than 1/8" in 10 feet.

3.03 REINFORCING
3.04 PLACING

A. Concrete: Convey and place concrete so there is no separation of ingredients in accordance with applicable requirements of Chapter 10 ACI Standard Specifications for Concrete Pavements and Concrete Bases (ACI 617-Current Edition). Do not place concrete when temperature is below 40 degrees F. No calcium chloride shall be added to the concrete. Do not place concrete which exceeds 95 degrees F., and add a retarder, if required, to all concrete which is between 90 and 95 degrees F. Ice shall be used to control the maximum temperature.

B. Construction Joints: Stoppage of concrete placing shall occur at expansion joint or other detailed contraction joints. Construct bulkheads to permit continuation of reinforcing steel.

C. Expansion Joints: Place 1/2" asphaltic expansion joint material where paving abuts existing paving, structure, walls or fixed objects. Place at every 60 feet each way in paving, every 30 LF in curbs and walks and at other locations detailed. Provide 1/2" wide expansion joint filler between curbs and concrete paving. Provide removable tacked-on strips to provide a recess for joint sealing compound. 3/4" Dowels, 24" long shall be placed at 24" O.C. through expansion joints, sleeved one side, at all expansion joints except where joint abuts building, unless noted otherwise.

D. Saw-Cut Contraction Joints: Saw-cut joints when concrete is hard enough not to be torn, raveled, or damaged by saw cutting equipment and no later than 10 hours after concrete placement. Trial cuts shall be made prior to execution. Use a power drive concrete saw. Saw blades shall make a clean, smooth cut, producing a groove 1/8" to 1/4" wide to depth required (1/4 slab depth). Locate contraction joints nominally at 12'-0" O.C., unless specified otherwise on Drawings. All joints shall receive sealant.

3.05 FINISHING

A. Materials exposed to view free of surface defects such as poor joints, ridges, cracks, honeycombing, excessive laitance, stone pockets or other defects. Materials that are defective and cannot be satisfactorily repaired, removed and replaced at the Contractor's expense.
B. Concrete cured by use of curing compound applied after surfaces take initial set after finishing. Use color matched curing system as recommended by manufacturer of integral color at colored concrete.

C. General Paving and standard Sidewalks: Finish surface to gritty texture with stiff bristle push broom using straight continuous strokes. Finish all edges smooth with 1/8” to 1/4” radius.

D. Ramps: Sawcut tactile warning surface to pattern indicated on drawings. Grooved shall be arranged so as to not hold water.

E. Vibrate, screed and float concrete to level and test the surface, which shall not vary over 1/4” in 10’ when tested with a ten foot straight edge.

F. Finish all vertical surfaces in a manner that leaves the exposed surfaces free of honeycombing and form marks. Any damaged surfaces shall be repaired and stone rubbed to match adjacent finished surfaces.

3.06 CURING

A. Apply a white-pigmented type curing compound at a uniform rate of approximately 200 SF/Gallon, or as recommended by curing compound manufacturer as soon as the finishing operation has been completed and the concrete has lost its water sheen. The curing procedure must protect the concrete, including all exposed surfaces against loss of moisture and rapid temperature change for a period of not less than four days from the beginning of the curing operations and without damage to, or marking of the finished concrete surface. Traffic shall not be allowed on finished concrete of a minimum period of seven days.

B. At colored concrete apply color matched curing system as recommended by the manufacturer.

3.07 CLEANING

A. Concrete approaches, sidewalks, and related work shall be hosed down with water, scrubbed with fiber brushes, allowed to dry and be left broom clean and in condition acceptable to the Owner.

END OF SECTION 32 13 13
SECTION 33 06 00

UTILITY SERVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Furnish all labor, materials, services, equipment and appliances required in conjunction with or properly incidental to the furnishing and installation of site drainage system complete as indicated on the Drawings and as specified herein, including:
      a. Layout of drainage and utility lines
      b. Excavation for trenching, de-watering and backfilling
      c. Reinforced concrete drainage structures and related covers, grates and frames
      d. Connection of drainage piping to existing drainage line
      e. Lateral drainage lines to locations indicated on Drawings for connection to roof drainage piping
      f. Water distribution system
      g. Sanitary sewer system
      h. Gas distribution system
      i. Removal of excess excavated material off-site
      j. Provide trench safety design as required for fire hydrant work.
   2. Systems shall start at a point approximately 5 feet beyond the exterior walls of the building and extend to termination unless otherwise indicated on the Drawings.

B. Related Documents: The Contract Documents, as defined in Division 1 Section - Summary of Work, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

C. Related Sections include the following:
   1. Division 01 Section “Information Available to Bidders - Geotechnical Report.”
   2. Division 22 Section “Connection to Building Systems.”
3. Division 32 Section “Excavating, filling, grading of site.”

1.03 QUALITY STANDARDS

A. Meet requirements and recommendations of applicable portions of the Standards listed.
   1. Applicable publications of local governing authority
   2. American Society for Testing and Materials, ASTM.
   3. Texas Highway Department Standard Specifications for Construction of Highways, Streets, and Bridges, 1972, THD.
   4. Texas Trench Excavation Law.

1.04 SUBMITTALS

A. Division 1 Section - Submittal Procedures: Procedures for submittals.

B. Product Data: Submit copies of manufacturer's literature showing details of fabrication and installation of valves, vaults, clean-out boots, fire hydrants, flush hydrants, concrete pipe, joint materials, covers, grates and frames.

C. Shop Drawings: Submit manufacturer's data showing details of precast concrete structures related with site drainage.

D. Certification: Furnish Owner a certification from pipe manufacturer stating that pipe conforms to Specification requirements.

1.05 TESTING

A. Listed herein a minimum testing requirements. Cost for making these tests will be paid for by the Contractor.

B. Backfill: One laboratory test, TEX 114-E, for soil density shall be made for each type of soil used as backfill material. When a test has been made previously on similar soil, a duplicate test will not be necessary.

C. Reinforcing Steel: Furnish the Architect a certification from the steel fabricator or manufacturer stating that reinforcing steel conforms to Specification requirements.

D. Portland Cement Concrete: Contractor may use mix design currently being used which meets Specification requirements. In lieu of this, provide samples of materials proposed for use in Portland Cement concrete. Testing laboratory will determine that cement and aggregates meet requirements of these Specifications. Laboratory shall then prepare mix design which conforms to Specifications. New mix design will be required if materials are changed or if concrete does not meet strength or workability requirements.
PART 2 - PRODUCTS

2.01 CONCRETE PIPES FOR STORM SEWER SYSTEM

A. Reinforced - ATSM C76 Class III Joints -
   1. Pipe of 12" diameter and over - Tongue and groove with neoprene or other approved gasket.
   2. Fittings and specials - Gasket type joints as required for pipe being connected.

2.02 CONCRETE STRUCTURES

A. Portland Cement: Shall be of a standard brand and shall conform to the latest ASTM designation C150, Type 1.

B. Aggregates for concrete: Fine or coarse aggregate and shall meet the requirements of THD, Item 421.

C. Concrete: Composed of Portland Cement, coarse aggregate, fine aggregate, water, mineral filler and/or admixtures, if permitted by the Architect. Concrete shall have a minimum compressive strength at 28 days of not less than 3000 psi and shall have a maximum water-cement ratio of 7.0 gallons per sack, minimum cement content of 5.0 sacks per cubic yard, and a slump from two (2) to three (3) inches. Measuring materials, batching, and mixing shall conform to ASTM Designation C94.

D. Reinforcing Steel: Conforming to ASTM Designation A615 of grade 40 or 60.

E. Cast Iron Rings, Covers, and Grates: Shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. Angles shall be filleted and arises shall be sharp and true. Surfaces shall be machined where indicated or where otherwise necessary to secure true, flat surfaces. Covers and grates shall fit properly into frames, and seat uniformly and solidly.
   1. Castings: Conforming to the following ASTM Designation:

      Gray-Iron Castings                  A48  Class 50
      Malleable Castings                 A47  35018
      Ductile Iron Castings              A395 60-45-15

   2. Trench Drain: Neenah Foundry Co. Type R-4990-C (Type A, B, or C Grate openings) with Type L Frame, or approved equal.

F. Inlets: Precast concrete inlets as indicated on the Drawings or approved equal.
2.03 CAST IRON PIPE

A. U.L. approved and accepted by State Fire Insurance Commission without penalty. Manufactured in accordance with Federal Specification WW-P-42, AWWA C1-6-53 (ASA A21.6) or AWWDA C108-53 (ASA A21.8), Class 150. Centrifugal cast pipe shall have metal thickness based on tensile strength of 18,000 pounds per square inch and modulus of rupture of 40,000 pounds per square inch. It shall be designed for five foot cover, trench condition B. For any variation in the above physical strength values, there shall be a corresponding variation in metal thickness based on the ASA approved formula in Manual for Computation of Strength and Thickness of Cast Iron Pipe (A21.1-1939).

1. Joints: One of the following types:
   b. Mechanical: AWWA C111 ductile iron or gray-iron glands, high strength bolts and nuts and rubber gaskets.

2. Gasket:
   a. American-Fastite Joint
   b. Lone Star-Bell-Tite Joint
   c. U.S.-Tyton
   d. or approved equal.

3. Fittings: AWWA C100-08 or C110-53 (ASA A21.10) bell and spigot type Class D, or AWWA C111-53 (ASA A21.11) mechanical joint type.

4. Lining: Outside tar coated, inside cement lined and sealed in conformance with AWWA C104-53 (ASA A21.4) except that cement lining may be half thickness in conformance with Federal Specification WW-P-421.

5. Solder Filler Metal: ASTM B32, Alloys Sn 95, Sn 94, ORE.

2.04 STEEL PIPE

A. Standard line pipe with plain ends, beveled for welding in random lengths, with welded fittings such as tube turns of same thickness as the pipe, unless otherwise required.

1. Flanges for connecting to valves - Forges steel welding neck designed for 150 PSI pressure, unless indicated otherwise.

2. Gaskets - 1/16" thick
   a. American Standard
   b. Rainbow
   c. or approved equal.

3. Tees for connecting service lines to main:
   a. For new empty mains: Mueller Brass Co., H-17701 and 17500 or approved equal butt-welded type.
b. For existing mains in use: Mueller Brass Co., H-17570 or approved equal.

2.05 PVC PIPING AND FITTING ASSEMBLY

A. Piping and Fittings: PVC plastic pipe AWWA C900, class 150 or 200 for water piping and provide with bell end and ASTM F 447 elastomeric seal gasket and plain end for PVC elastomeric gasket fittings. ASTM D 3034, SDR 35 for sewer piping.

B. Gaskets: ASTM F 477, elastomeric seal.

C. Solvent: ASTM D 2564, use type and procedures recommended by pipe manufacturer to make solvent-welded joints. Thoroughly clean pipe and fitting of dirt, dust, and moisture before applying solvent.

D. PVC to Metal Connection: Work metal connection first. Use a non-hardening pipe dope such as Permatex No. 2 on threaded PVC to metal joints. Use only light wrench pressure.

E. Threaded PVC Connection: Where required, use threaded PVC adapters into which pipe may be welded.

F. Plastic Underground Warning Tapes: Polyethylene plastic tape, 6 inches wide by 4 mils thick, solid green in color with continuously-printed caption in black letters “CAUTION - SEWER LINE BURIED BELOW.”

2.06 FIRE HYDRANTS

A. Conforming to AWWA Standard C 502-54 dry barrel type traffic mode with 5" minimum diameter valve opening. Mueller Brass Co. - A -24123, or approved equal.

2.07 TAPPING SLEEVE AND VALVE

A. Suitable for tapping cast iron water main under pressure and having a mechanical end joint. Kennedy Valve Company - 950X, or approved equal.

2.08 GATE VALVES

A. Water distribution - Designed for 150 pounds per square inch minimum working pressure. End design to conform to piping design. Clear waterway through valve shall equal nominal diameter of the valve. Valve shall have a 2” square operating nut
turning counter clockwise to open with direction indicated by an arrow cast in the metal.

1. Sizes less than 2" - Of brass conforming to Dereal Specifications WW-V-54, Type 1, Class B.
2. Sizes 2" to 4” - Having cast iron body, brass-mounted, conforming to Fed Spec WW-X-58, Class A or AWWA standard C500, double disk type, non-rising stem.
3. Sizes 4” and larger for fire protection - Nonrising Stem, UL 262, FM approved, iron body and bonnet with flange for indicator post, bronze seating material, inside screw, 175-psig (1200 kPa) working pressure, mechanical joint ends. Provide with flanged ends for pit installation.

B. Gas system - Cast iron wading type with cover marked "G" or "GAS"

C. Gas Distribution - Double disc type with parallel seat, non-rising stem, bronze mounted, with flanged end, designed for 176 pounds per square inch minimum working pressure. Mueller Brass Co. - A-2483-6, or approved equal.

2.09 STOP COCKS

A. Cast iron body, designed for 125 pounds per square inch working pressure. Mueller Lub O SEAL, H-11170 and H-11175, or approved equal.

2.10 VALVE BOXES

A. Water system - Of cast iron complete with lock-type cover operated by a special wrench and having the word "WATER" cast in the cover. Boxes shall be of the extension type with screw or slide-type adjustment and with flared base. Metal shall be 3/16" minimum thickness.

2.11 CLEAN OUT BOOTS

A. Cast iron ferrule and countersunk brass cleanout plug, with round cast iron access frame and heavy duty, secured, scoriated cast iron cover shall be Trinity Valley 1684, or approved equal.

2.12 BACKFILL MATERIAL:

A. Borrow: Reused excavated or equal borrow material; low expansiveness, uniform in grade, free from organic materials, capable of being compacted to 95 percent maximum density at optimum moisture content; ASTM D-698.

1. Sand: Natural river or bank sand; free of silt, clay, loam, friable or soluble materials, and organic matter; graded in accord with ASTM C136.
B. Bedding:
1. Washed gravel, 1/4" to 1-1/2" in size.
2. Screened pit run gravel passing 1-1/2" sieve and retained on 1/4" sieve.

PART 3 - EXECUTION

3.01 GENERAL

A. The Contractor shall furnish all labor, tools, materials and incidentals required to complete the work.

B. The Contractor shall lay out all work included herein and shall determine the elevations of existing piping at all tap locations and furnish that data to the Owner for review of flow capacity.

3.02 EXCAVATION:

A. The Contractor shall excavate all materials encountered regardless of the difficulties encountered. The ditch shall be no greater in width or depth than is necessary to permit construction in accordance with the plans and specifications. The maximum width of trench at top of pipe without sheeting, shoring and bracing shall be the external diameter of the pipe plus eight inches.

B. The Contractor shall determine the need for sheeting and bracing to safeguard the workmen. When sheeting and bracing are necessary the trench or excavation shall be dug to such width that proper allowance is made for the space occupied by the sheeting. All sheeting, shoring and bracing shall have sufficient strength and rigidity to withstand the pressure exerted and protect all persons or property from injury or damage. Sheetimg, shoring and bracing shall not be left in place, but shall be removed in such a manner as not to endanger or damage new or existing structures. All holes or voids left by the removal of sheeting shall be backfilled.

C. Soft, Spongy or otherwise unstable material which will not provide a firm foundation for the pipe shall be removed and replaced with suitable material from the excavation or other sources approved by the Architect and shall be compacted as provided for in the Specifications. When unstable conditions are not corrected by the above means, the Contractor will be required to use rock, gravel, concrete or timber foundations. The type of foundation shall be determined by the Architect. There will be no extra compensation for this work.

3.03 BEDDING:
A. Trenches for pipe shall be excavated to a minimum depth of three inches below the grade of the outside of the pipe. Trenches shall then be filled up to and around the pipe exterior for at least 15 percent of its overall height with one of the following materials:

B. Other type of bedding shall be provided when designated on the Drawings.

3.04 BACKFILL:

A. After the pipe has been installed, selected material from the excavation at a moisture content with which the required density can be obtained shall be placed equally along both sides of the pipe in layers not exceeding six inches loose depth. Care shall be taken to insure thorough compaction of the fill under the haunches of the pipe. Each layer shall be thoroughly compacted by hand or pneumatic tampers until the fill has reached an elevation 12” above the top of the pipe. The remainder of the backfill shall be placed in layers not exceeding 10” loose depth and shall be compacted by an approved method which will obtain the density of the adjacent undisturbed soil. Backfill for utilities under pavements and curbs and gutters shall be compacted in 6” layers to a density not less than 95 percent of maximum density at optimum moisture content of Standard Proctor Density. Water jetting will not be permitted.

1. Structures: Place backfill, as far as possible, as the work progresses, evenly on all sides of the structure. Remove forms, shoring, sheeting, bracing, etc., before starting to backfill and do not backfill against concrete until directed, which in general shall be at least 7 days after placement. Take care to prevent any wedging action of backfill against structure.

3.05 STORM SEWER SYSTEM

A. No pipe shall be laid until it has been inspected and approved. All pipe shall be laid and jointed in the dry. The pipe shall be laid up-grade beginning at the lower end of the line. Pipe shall be laid accurately to line and grade. When the entire pipe has been checked for line and grade, the body of the pipe shall be back-filled with enough earth or concrete on both sides to hold the pipe firmly in position.

B. Wye Connections: The connection of one pipe to another may be accomplished with a precast wye or by means of pipe-to-pipe connection. A pipe-to-pipe connection shall be made by cutting a hole in the larger pipe slightly larger than the outside diameter of the pipe to be connected. The smaller pipe to be connected shall not project into the larger pipe. A concrete collar not less than 6” thick and 6” wide shall be placed around the smaller pipe on the exterior surface of the larger pipe.

C. End-to-end Connections: Whenever a smaller pipe is jointed end-to-end to a larger pipe, the inside tops of the two pipes shall be matched. The void between the pipes
shall be filled with cemented brick work or where this is not possible the void shall be filled with concrete or mortar. In either case, a concrete collar not less than 6" thick and 6" wide shall be placed over the joint.

3.06 SANITARY SEWER SYSTEM

A. Pipe: As required per City specification.

B. Location: Where specific dimension is not shown, sewer shall be located at least 10' horizontally from any water supply or service line. Crossing above water lines: Construct gravity sewers which pass over water lines of Cast Iron Pipe for a distance of 9' each side of the crossing. No joint shall occur within 3' each side of the crossing.

C. Laying Pipe: Shape the bottom of the trench to give substantial uniform circumferential support to the lower fourth of the pipe. Lay pipe proceeding upgrade with the spigot ends of the bell and spigot pipe and the tongue ends of tongue and groove pipe pointing in the direction of flow. Lay each section true to line and grade in such a manner as to form a close concentric joint with the adjoining pipe and to prevent sudden offsets of the flow lines. As the work progresses, clear the interior of the pipe of all dirt and superfluous material. Where cleaning after laying is difficult due to small pipe size, keep a suitable swab or drag in the pipe and pull it forward past each joint immediately after the jointing is complete. When work is not in progress, plug the ends closing them by another approved method. If maximum width of the trench at the top of the pipe exceeds the specified dimension for any reason other than by direction, provide at no additional cost such concrete cradling, pipe encasement or other bedding as may be required to satisfactorily support the added load of backfill.

D. Infiltration: Leakage into the sewer shall not exceed 500 gallons per inch of nominal diameter per day per mile of pipe for any section between successive manholes. If the infiltration rate does not appear to be acceptable, measure the amount of leakage with a suitable weir or other device as directed. If the measured rate of infiltration exceeds the acceptable maximum, make correction in the system until it becomes acceptable.

E. Manholes: Construct manholes of precast concrete sections or of brick. Covers and frames shall be of cast iron. Invert channels shall be smooth and semi-circular in shape, conforming to the inside of the adjacent sewer section. Make changes in direction of flow with a smooth curve of as large a radius as the manhole size will
permit. Changes in size and grade of the channels shall be made gradually and evenly. Form the invert channels directly in the concrete of the manhole base or by use of a half tile laid in concrete, or by laying full-section sewer pipe through the manhole and breaking out the top half after surrounding concrete has hardened. The floor of the manhole outside the channels shall be smooth and shall slope toward the channels not less than 1" per foot nor more than 2" per foot. Free drop inside the manhole shall not exceed 2'-6" measured from the invert of the inlet pipe to the top of the floor of the manhole outside the channels. Construct drop manholes whenever the free drop would otherwise be greater than 2'-6". In all manholes, provide steps of cast iron. Width of steps shall not be less than 10", set them approximately 15" apart and with alternate steps off-set 6". Rungs of 7/8" diameter wrought iron, galvanized after fabrication, may be substituted for steps and may be installed without offset if the crossbar is not less than 14" long. Rungs shall be formed so that crossbar is sufficiently below plane of side bar to prevent foot from slipping off. Provide not less than 6-1/2" of toe room at each rung, measured from inside face of the crossbar.

F. Clean-outs and Stacks: Use pipe of the same material as the mainline and of 6" diameter unless shown otherwise. Provide removable standard pipe plugs.

G. Testing: Sewer mains will be checked to determine any displacement of the pipe after trench has been backfilled 2' above the pipe and compacted. Testing shall be with a light flashed between manholes or manhole location. If poor alignment or displacement or other defects are discovered, they shall be corrected as directed.

3.07 WATER DISTRIBUTION SYSTEM

A. Pipe Material and Preparation: Use PVC pipe. Before lowering pipe into trench, clean the interior of all foreign matter, inspect the pipe for defects. Defective, damaged or unsound pipe must be removed from the site.

B. Laying Pipe: The full length of each pipe section shall rest solidly upon the pipe bed with recesses excavated to accommodate bells and joints. Keep pipe interior clean and dry during laying operations. When work is not in progress, plug the ends or close them by another approved method. Do not lay pipe with bells facing in direction of laying. Do not lay pipe closer than 10' to a sewer. At cross-overs with sewers, no joint in the water line shall be closer than 9' from the cross-over point. Where possible, lay water lines 6' above sewers at cross-overs. Provide valves, plugs or caps, as required, where pipe ends are left for future connections. Deflections from a straight line or grade as required by vertical or horizontal curves of off-sets shall not exceed 6/D inches per lineal foot of pipe, between the center lines, extended, of any 2 connecting pipes. D represents the nominal pipe diameter in inches. If alignment requires deflection in excess of this limitation, use special bends or a sufficient number of shorter lengths of pipe to provide angular deflections within the limits.
C. Cutting Pipe: Use an approved type of mechanical cutter. Use wheel cutters when practical.

D. Pipe Joints: Install Mechanical Joints according to joint manufacturer's recommendations. Center the spigot in the bell, push the pipe in position and bring it into required alignment.

E. Valves: Where feasible, locate valves outside the area of roads and streets. Set valves plumb. Unless shown otherwise, provide a valve box over each outside gate valve. Box shall be of such length as will be adapted, without full extension, to the depth of cover required over the pipe at its location. Center the box on the valve. Carefully tamp earth fill around the box to a distance of 4' on all sides or to the undisturbed trench face if less than 4'.

F. Fire Hydrants: Set the hydrant plumb and at such elevation that the connecting pipe will not have less cover than the distributing mains. Provide a concrete slab for the hydrant as required. Secure the hydrant to prevent it from blowing off the line with a concrete thrust block set between the back of the hydrant, opposite the pipe connections, and the vertical face of the trench. If the character of the soil is such that the hydrant cannot be wedged in this manner, provide bridle rods and rod collars of not less than 3/4" stock and protect them with a coating of acid resisting paint. Place at least 5 cubic feet of broken stone around the hydrant base to insure drainage. Thoroughly compact the backfill around hydrants to grade.

G. Flush Hydrants: Install where required so as to be flush with finished edge.

H. Meter and Meter Vault: Valves and fittings in meter vault shall be bolted flange type with ring gaskets.

I. Meter Vault: Per City Specifications.

J. Anchorage of Fittings: Anchor tees, bends and plugs in mains with thrust blocks formed of 2,500 p.s.i. 28 day strength concrete.

K. Sterilization: Sterilize each unit of completed distribution system, using chlorine, before it is accepted for domestic operation. If possible, flush the lines thoroughly before introduction of chlorinating material. The amount of chlorine shall be such as to provide a dosage of at least 50 parts per million. The chlorinating material shall be introduced into the system by an approved method. It shall remain in the system for a contact period of at least 24 hours and until the pressure test required below is complete. During this time valves in the system shall be opened and closed several times. After the contact period, flush the system with clean water until the residual chlorine content is depleted or not greater than 0.5 part million. Then take Bacteria samples as directed and submit them to the State Health Department Laboratory for analysis. Final results of the test shall indicate no chlorine bacteria present in the samples. Water mains shall meet State Health Department requirements before acceptance.
L. Testing: During sterilization contact period, test the system. Piping shall have been laid, joints completed and trench partially backfilled but leaving the joints exposed for examination. Unless otherwise required, expel air in the line and subject it to a hydrostatic pressure test of 50 pounds per square inch in excess of the anticipated static pressure at the points of reading when the system is pit in operation. Maintain the pressure for one hour. Exposed pipe, joints, fittings, valves and accessories shall be inspected. Tighten or remake defective joints. Replace defective material and repeat the test until results are satisfactory. Conduct open trench tests for 2 hours and covered trench tests for 24 hours. Provide all plugs, valves, pumps, equipment and labor necessary for conducting the tests. Assume responsibility for damage and/or contamination to existing connecting supply mains.

M. Special Requirements: Where conditions prevent the actual visible inspection of each joint or when the joints are made of a material other than lead such that leakage diminishes as the material in the joints ages, provide a calibrated gauge and meter to determine the quantity of water lost by leakage under normal operating pressure. To be accepted, any leakage (evaluated on a pressure basis of 150 pounds per square inch) must be less than 100 U.S. gallons per 24 hours per mile of pipe, per inch nominal diameter or pipe for pipe in 12 foot lengths, 75 gallons for pipe in 16 foot lengths, and varies proportionately for other pipe lengths. In calculating leakage, make allowance for added joints in the pipeline above the normal for unit lengths of pipe. Should any test of combined sections of pipeline disclose leakage greater than the acceptable limit, make repairs until the leakage is reduced to, at most, the acceptable limits.

3.08 CLEAN UP

A. Upon completion of the work covered by this Section, the Contractor shall clean up all work areas by removing all debris, surplus materials, and equipment from the site. The ground surface shall be restored to its original condition as nearly as possible.

3.09 PROTECTION

A. Properly protect existing utility lines shown on the Drawings from damage due to these operations. If damage occurs, satisfactorily repair it at no additional cost. If damage occurs to an unknown line, give immediate notification.

END OF SECTION 33 06 00